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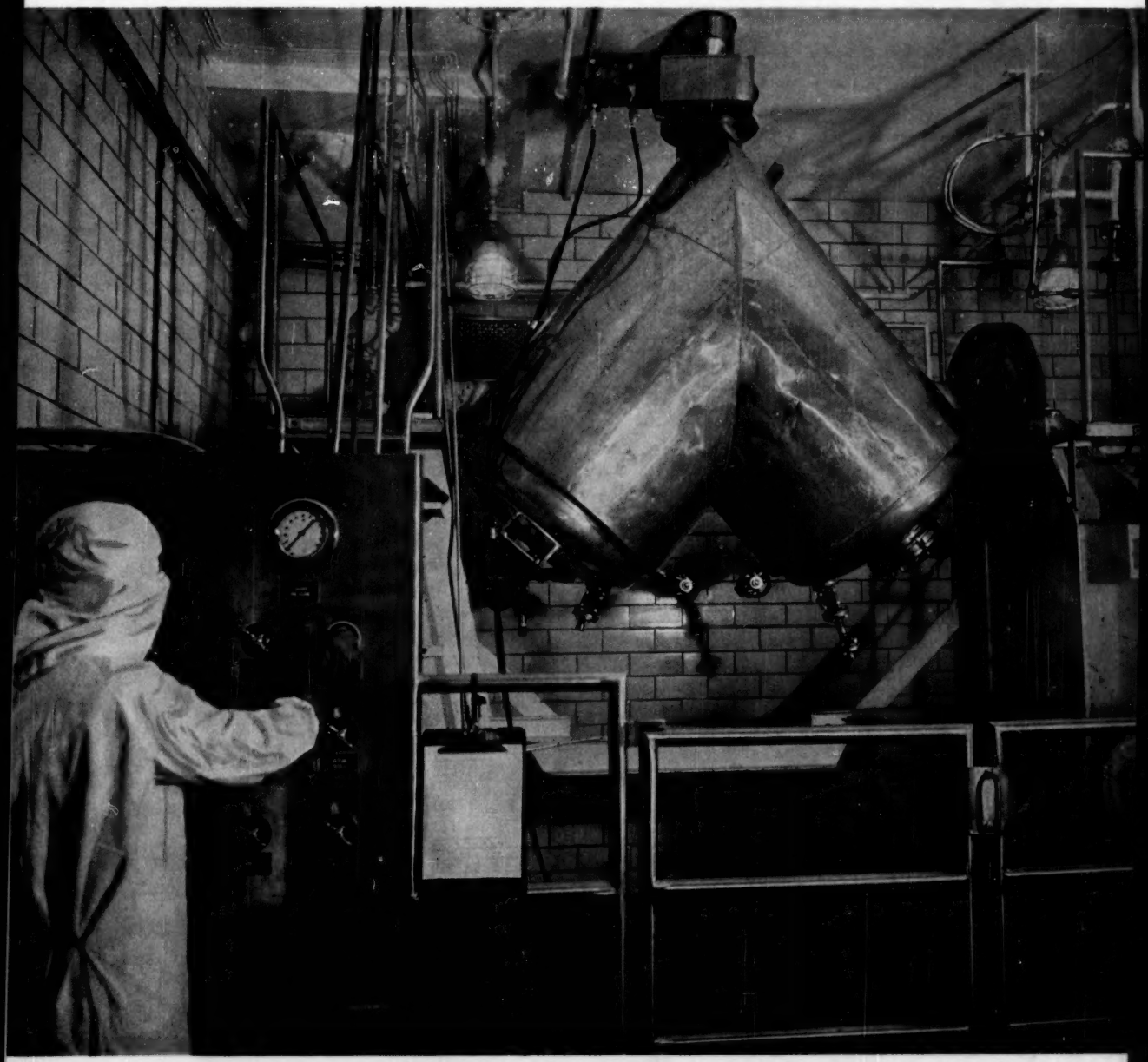

A CE FEATURE REPORT: SOLID-SOLID BLENDING

page 107
(Complete contents, page 3)

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Epon 836-C-75	836	MIBK	75
Epon 1001-A-80	1001	Acetone	80
Epon 1001-B-80	1001	MEK	80
Epon 1001-BT-70	1001	MEK/Toluene (50/50)	70
Epon 1001-CX-75	1001	MIBK/Xylene (65/35)	75
Epon 1001-T-75	1001	Toluene	75
Epon 1001-X-75	1001	Xylene	75
Epon 1007-CT-55	1007	MIBK/Toluene (50/50)	55

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Bird Continuous Solid Bowl Centrifugal Separation of Solids from Liquids *Any Way You Want:*

Capacity? A Bird was installed in a sulphate pulp mill to deliver 100 tons of dewatered lime mud per day. As mill output has increased it is turning out 195 tons per day, 24 hours a day, 7 days a week with no increase in maintenance expense.

A small (18″) Bird is dewatering and washing salt crystals from an organic solution at the rate of 7000 lbs. per hour. The discharged salt contains only 3% moisture and 99% plus of the organic material is recovered, using less than 0.2 lb. of water per lb. of salt.

Separating efficiency? A Bird is used for the final pass of a countercurrent extraction of high gamma benzene hexachloride. It must be fume tight as the solvent is methanol. Handling 28,000 lbs. of dry weight solids per day with feed consistency 32% solids at 25°C, the solids discharge contains less than 5% solvent and the filtrate is essentially clear.

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Flexibility? Installed to handle a very difficult filtering job on an extremely fine material, Birds were suddenly shifted to handling relatively coarse solids due to a change in process. Results continued excellent without new equipment, alterations or parts changes. Could any other type of filter do this?

You Name It. The beauty of the Bird is that it can be designed and built to fit *your* deliquoring specifications, *your* filtrate clarity requirements. It comes in seven sizes with twenty-five possible design variations in each size.

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August 8, 1960 **Chemical Engineering** Vol. 67, No. 16

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* FREE—for your files—Check Reader Service postcard (p. 186) for an extra copy fo these iconoclastic observations about a preceding article on speech-making.

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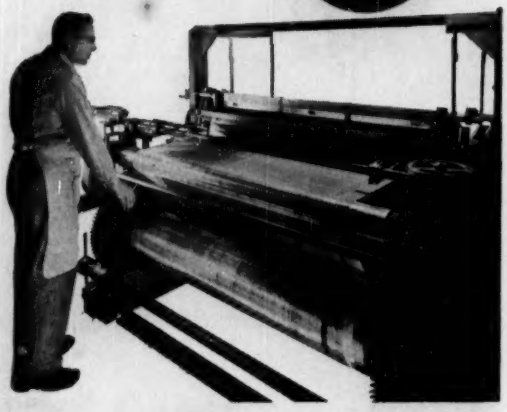
platinum, platinum-palladium and platinum-rhodium-palladium alloy gauze catalysts for industry

BAKER PLATINUM DIVISION



The catalytic properties of the platinum metals, plus their corrosion resistance at extreme temperatures, enable gauzes made from these materials to be utilized as the only practical catalysts for various commercial chemical reactions.

Despite the initial expense encountered in the purchase of the precious metal gauze, the investment for the catalyst is only a very minor factor in the final cost of the finished product. Generally, platinum gauze catalyst is the basis for the most efficient and economical catalytic procedures. The uses for platinum and platinum alloy gauze in the chemical industry include the manufacture of nitric acid, chamber sulphuric acid and hydrocyanic acid.

Engelhard research and experience in the development of platinum gauze catalysts for the chemical industry is at your service. Write for literature.

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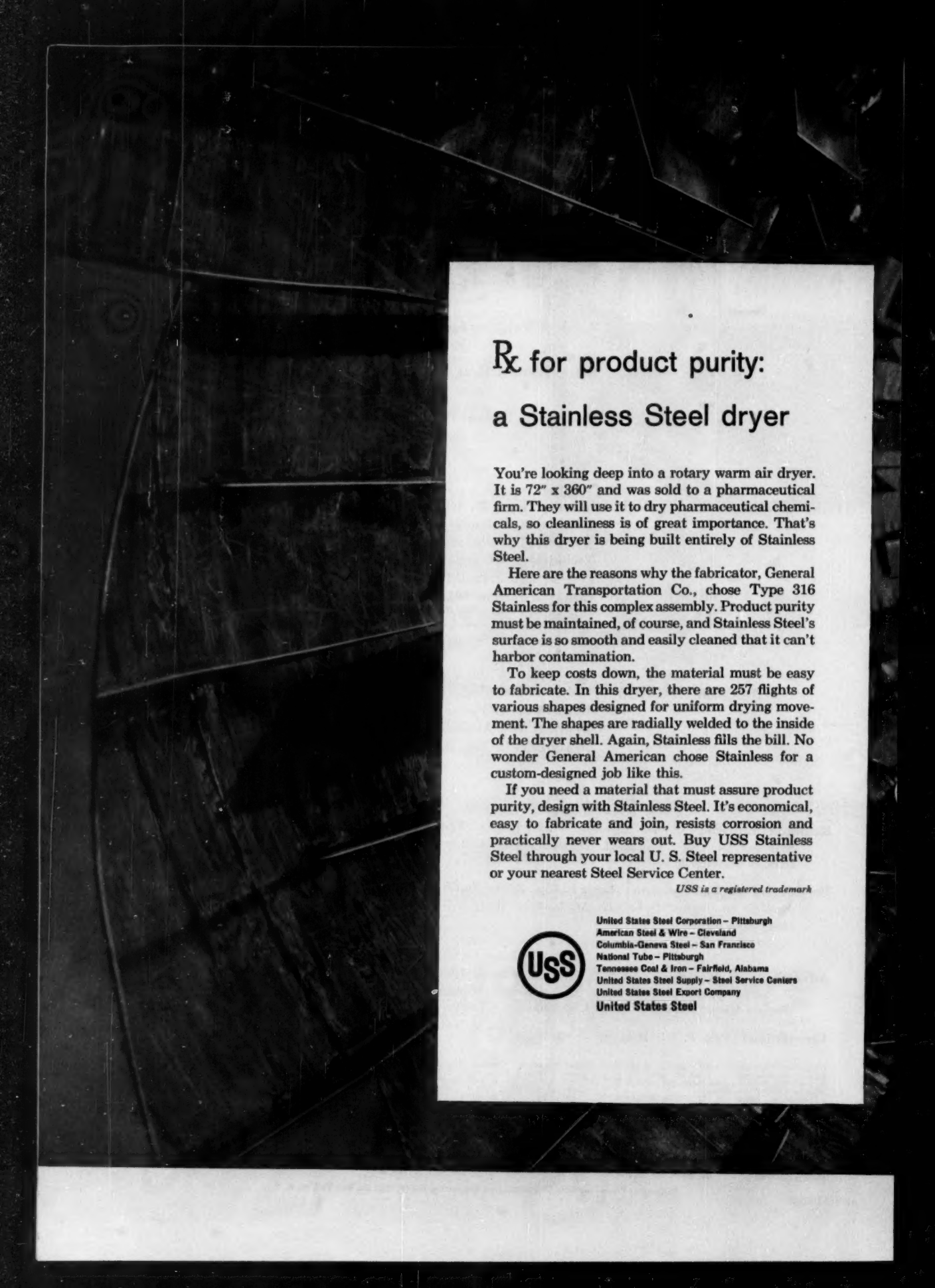

Rx for product purity:

a Stainless Steel dryer

You're looking deep into a rotary warm air dryer. It is 72" x 360" and was sold to a pharmaceutical firm. They will use it to dry pharmaceutical chemicals, so cleanliness is of great importance. That's why this dryer is being built entirely of Stainless Steel.

Here are the reasons why the fabricator, General American Transportation Co., chose Type 316 Stainless for this complex assembly. Product purity must be maintained, of course, and Stainless Steel's surface is so smooth and easily cleaned that it can't harbor contamination.

To keep costs down, the material must be easy to fabricate. In this dryer, there are 257 flights of various shapes designed for uniform drying movement. The shapes are radially welded to the inside of the dryer shell. Again, Stainless fills the bill. No wonder General American chose Stainless for a custom-designed job like this.

If you need a material that must assure product purity, design with Stainless Steel. It's economical, easy to fabricate and join, resists corrosion and practically never wears out. Buy USS Stainless Steel through your local U. S. Steel representative or your nearest Steel Service Center.

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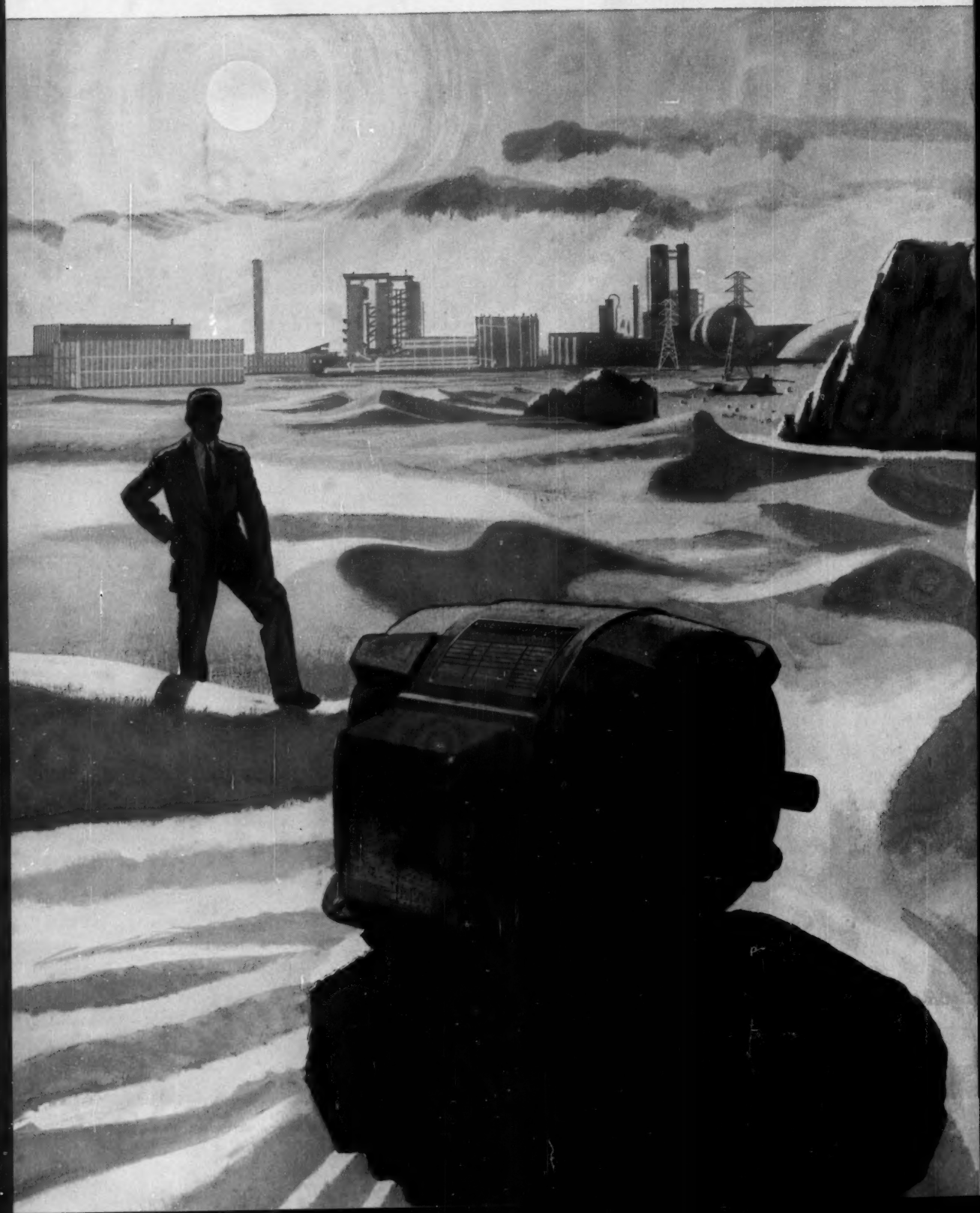
This mark tells you a product is made of modern, dependable Steel.

New Guardistor

THE MAN & THE MOTORS



FROM WESTINGHOUSE

Guardistor motors let you match the full capability of the motor to the job— with complete safety—absolute confidence

Our Marketing Manager says:

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
- Eliminates time and expense of changing winter-summer heaters. No nuisance tripping, it's fail-safe . . ."

Our Engineering Manager says:

"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark

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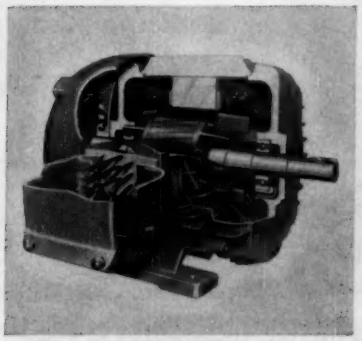
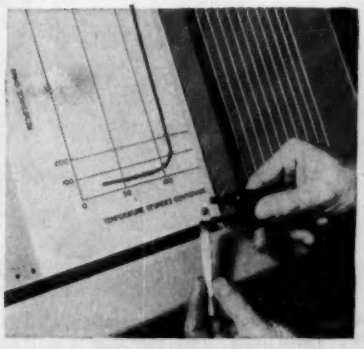


Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

MOTOR & GEARING DEPARTMENT

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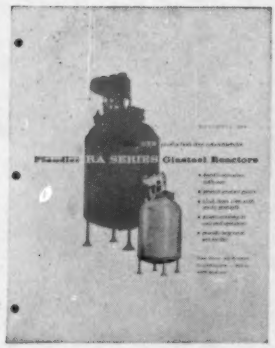
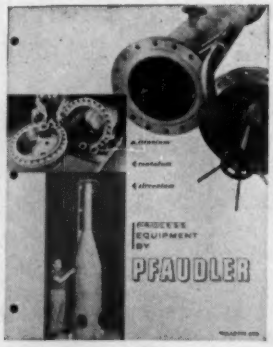
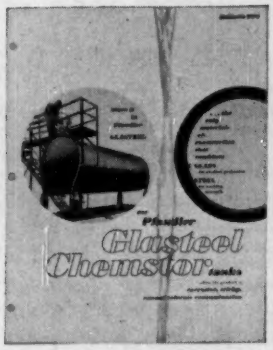


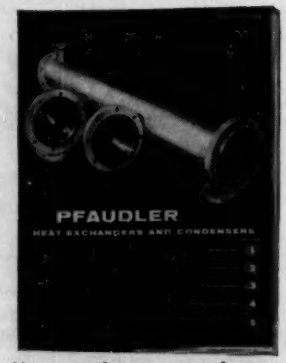
The latest in reactors. The new RA Series of Pfaudler® Glasteel Reactors offers many important design features—mirror-image top head, offset bottom outlet, engineered agitation, and choice of sizes through 4,000 gallons. Facts on the ability of Glasteel 59 to stand up to thermal shock and harsh corrosives, plus layout drawings and specs, are found in **Bulletin 988.**



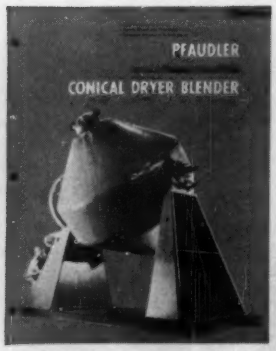
"New" metals for process equipment. Tantalum, titanium and zirconium are finding increased use because of their exceptional corrosion resistance and strength. Corrosion data, along with information on heat transfer and general applications are spelled out, and available equipment pictured, in our **Bulletin 978.** Check the coupon on the facing page.



The economies of Glasteel storage. For products that are corrosive, sticky, or cannot stand contamination, Glasteel storage tanks offer a sound solution. Savings accrue through long life . . . are immediate in sizes over 10,000 gallons, since Glasteel tanks cost less than stainless or clad steel. Vertical and horizontal designs in 500 to 35,000 gallons. **Bulletin 975.**

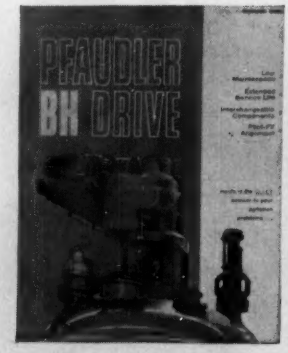


Heat exchangers and condensers. A valuable technical reference for engineers who specify tubular heat exchangers. Covers applications, typical installations, nozzle locations, construction materials, and various designs. Tables show relevant data on pressure loss, conductivity, fouling resistances, and physical properties of many heating media. **Bulletin 949.**

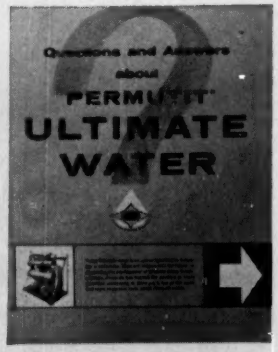


A versatile dryer blender. With the Pfaudler Glasteel Conical Dryer Blender you can also impregnate, concentrate, react and coat in one operation. Protects product purity, inhibits adherence, processes corrosives, reduces materials-handling time and conserves floor space. Details about construction, applications, and operating data in **Bulletin 963.**

Continuous self-desludging centrifuge. The Pfaudler Titan Superjector is increasingly popular for separating a wide variety of chemicals, pharmaceuticals, fats and oils. Unusually high separating power with controlled desludging through wide slots in bowl promotes higher concentration of solids with no danger of plugging. Six models described in **Bulletin 946.**



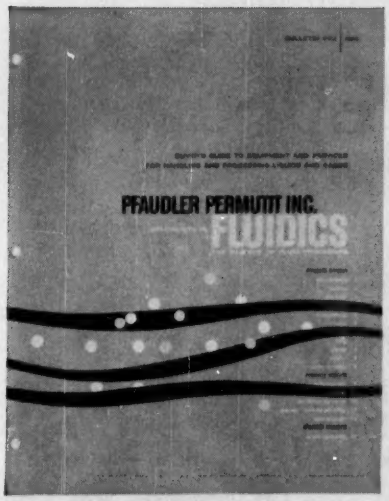
The quiet answer to agitation. The Pfaudler BH Drive offers a number of advantages including: increased critical agitator speed, reduced agitator shaft whip and runout, maintenance-free (up to 300,000 hours) anti-friction bearings, and special gears that provide quiet operation at all speeds. Three models. Horsepower range and dimensions in **Bulletin 996.**



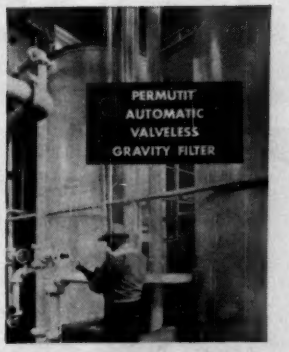
Ultimate water. Here's water so free from mineral contaminants that its purity can be measured only by its electrical resistivity. Recently issued booklet tells what ultimate water is, where used, how obtained, and covers storage, recovery, regeneration, installation and capacity of units used in making. Check the coupon for your copy of **Bulletin 4623.**

***FLUIDICS** is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

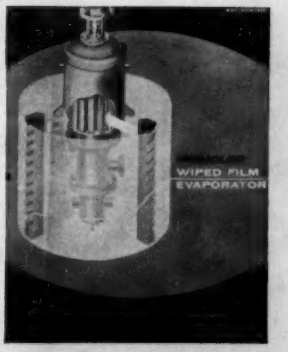
on FLUIDICS*



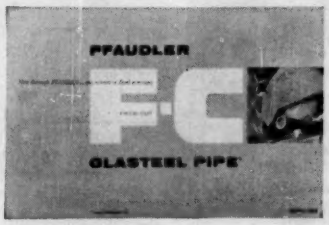
How FLUIDICS works for you. This buyer's guide describes the range of equipment for handling corrosives, heat transfer, reactions, centrifugal separations and packaging. It further covers water and waste treatment, ion exchange, gas analysis, metering and control. Discusses available design and engineering services for complete plants or process systems. Check coupon for **Bulletin 992.**



Save money with a valveless filter. The Permutit® Automatic Valveless Filter costs up to 45% less than conventional filters. It also saves you money after you install it, since filtering is accomplished without a single valve, agitator, pump, flow controller—or even an attendant operator. Diagrams and operating specifications in **Bulletin 4351.**



Evaporating "problem" products. The Pfaudler Wiped Film Evaporator is especially efficient in handling products that are heat sensitive, highly viscous, or low in thermal conductivity. Read details of unique positively wiped wall and full specifications on sizes, capacities and operating characteristics in our **Bulletin 991.**



F-C Glasteel pipe† you can "field cut." This new pipe can be readily installed in the field. Inside the pipe is ⅛"-thick glass for corrosion resistance and product protection; outside, steel for strength. Cut it on any standard dry abrasive wheel; thread, fire polish; thread on flange and belt sand. More facts and installation instructions in **Bulletin 989.**
†Patent applied for

PFAUDLER PERMUTIT INC.

Pfaudler Div., Dept. CE-80, Rochester 3, N. Y.

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- ☐ 975 Glasteel Storage
- ☐ 949 Pfaudler Heat Exchangers & Condensers
- ☐ 963 Conical Dryer Blender
- ☐ 946 Pfaudler Titan Superjector
- ☐ 996 Pfaudler BH Drive
- ☐ 4623 Questions and Answers about Permutit Ultimate Water
- ☐ 992 FLUIDICS BUYER'S GUIDE
- ☐ 4351 Permutit Valveless Filter
- ☐ 991 Wiped Film Evaporator
- ☐ 989 Pfaudler Glasteel FC Pipe

Name.....

Title.....

Company.....

Address.....

City.....Zone.....State.....

No alignment worries! LINK-BELT bucket elevators go

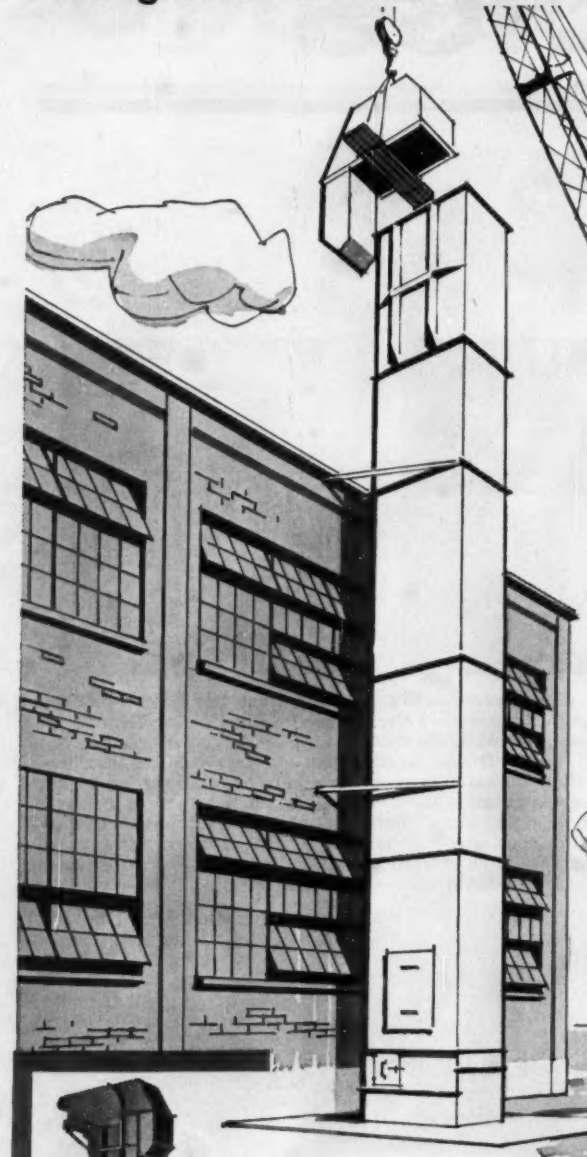
straight up... fast and easy

Factory-aligned components assure low-cost installation, smooth performance

Yes, Link-Belt bucket elevators go up easy . . . and they go up *straight!* There's no misalignment to cause inefficiency, bucket and casing wear.

Link-Belt manufactures *all* bucket elevator components . . . eliminates installation and operational problems in the *factory,* not in the field! All components are carefully designed and manufactured. Casings are jig-welded for perfect, ready alignment. Result: Unnecessary erection costs and difficulties are avoided, long-lasting efficiency assured.

Link-Belt will gladly erect your elevator (large or small) and accept full installation responsibility. For details, contact your nearest Link-Belt office. 15,207



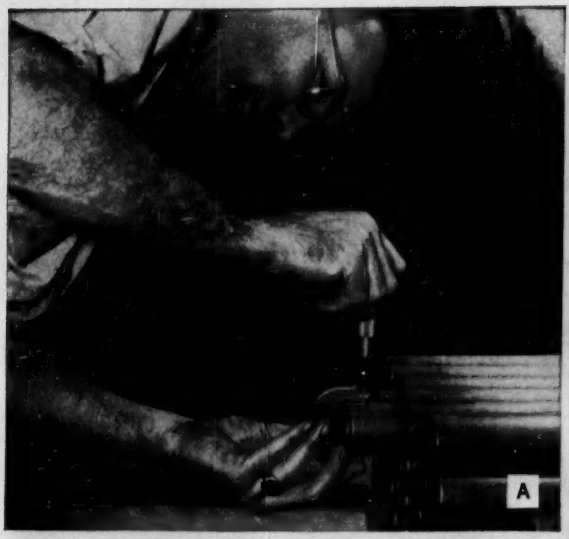
CENTRIFUGAL DISCHARGE bucket elevators are designed to handle free-flowing, fine and loose materials with small to medium lumps. Type 14 (shown) is built for high capacities.

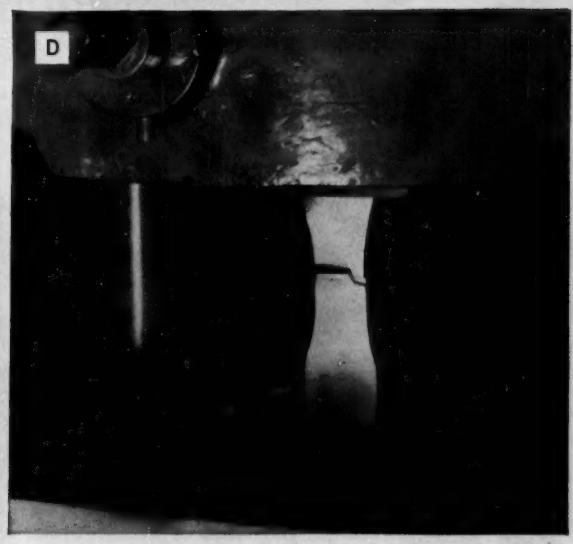
Link-Belt's complete bucket elevator line includes 14 types in 4 basic designs . . . centrifugal, positive, continuous and internal discharge. Also a wide variety of buckets . . . steel, malleable iron, Promal or alloy metals.

LINK-BELT

BUCKET ELEVATORS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.





Our testing team works for you

Your requirements come first with our testing team. Working directly under our chief engineer, they check and double-check the fabrication work of our production crews. Your own men couldn't do a more faithful job. Come and see for yourself. Or write for Bulletins HE and CI.

A **For a close fit**—Incoming tubes are always miked for exact size. Matching tube sheets are then reamed for a close fit that contributes to heat exchanger quality.

B **Tailored to size**—Quality dictates precise tube hole diameter. Constant micrometer checking tells our inspector that tube sheets are exactly right to meet your specs.

C **In the dark**—but not for long. Our own darkroom permits immediate developing of X-ray films... gives our inspector a fast check of weld structure and soundness.

D **Reply requested**—Our inspectors get many prompt reports from our own testing lab. Here's a tensile test on our own machine. It helps speed testing and inspection.

Downingtown Iron Works, Inc.

140 Wallace Ave., Downingtown, Pennsylvania

division of PRESSED STEEL TANK COMPANY Milwaukee

Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

DOWNINGTOWN IRON WORKS
Hackney

Dann Goodson, *Manager Motor-Driven Compressor Sales, The Cooper-Bessemer Corporation, explains...*

How Cooper-Bessemer's new, compact Air Compressors simplify installation and reduce costs

The DMR compressors shown here are two models of a new line of *compact, 720 rpm* machines, unmatched in reliability. With these units, Cooper-Bessemer introduces a new standard of installation economy. So highly compact, the DMR compressors are readily installed in existing space, avoiding the need for additional housing facilities. They can be located at strategic points throughout the plant to supplement existing air line services without additional feeders to help supply your production needs at minimum cost.

The new DMR units come completely equipped with integral motor-drive and intercooler... ready for operation. Their control can also be integrally mounted as shown. They are available for two-stage applications in the range of 500 to 2000 cfm and discharge pressures of 80 to 125 psi... also for single-stage and three-stage operation.

The introduction of this new line of air compressors, plus the portable tool facilities of our new subsidiary, The Rotor Tool Company, enable Cooper-Bessemer to give you full-scope service for your industrial air power needs. Call the nearby Cooper-Bessemer office or air compressor agent for Bulletin No. 94 on the new DMR line.

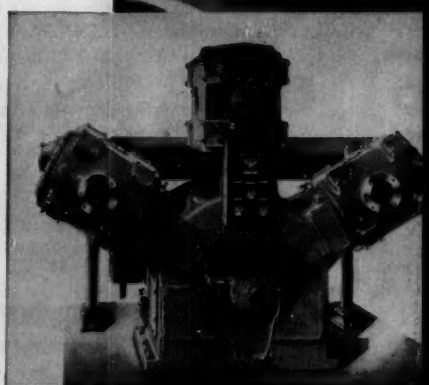
BRANCH OFFICES: Grove City • New York • Washington • Gloucester • Pittsburgh
Chicago • Minneapolis • St. Louis • Kansas City • Tulsa • New Orleans • Shreveport
Houston • Greggton • Dallas • Odessa • Pampa • Casper • Seattle • San Francisco
Los Angeles

SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd.... Edmonton • Calgary
Toronto • Halifax • Stratford
C-B Southern, Inc.... Houston
Cooper-Bessemer International Corp.... New York • Caracas • Anaco
Cooper-Bessemer, S.A.... Chur, Switzerland • The Hague, Netherlands • Mexico City
The Rotor Tool Company... Cleveland

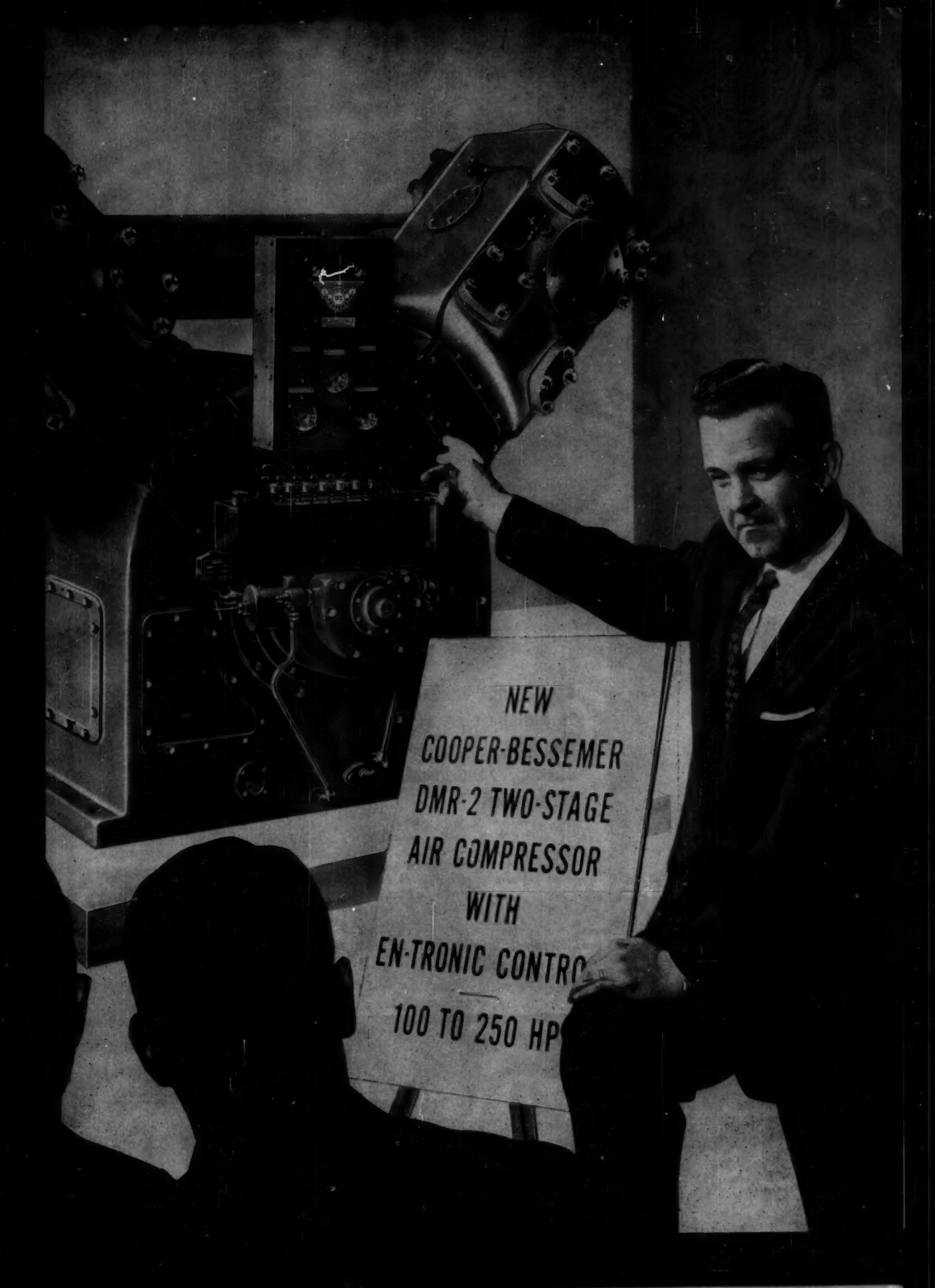
Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

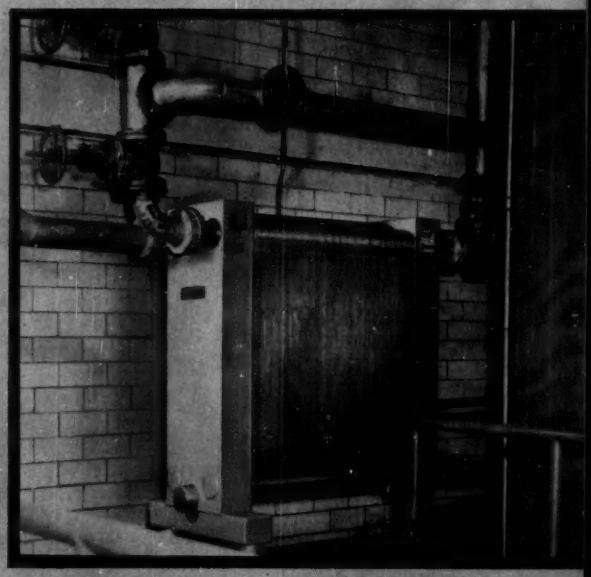
ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN



New DMR-3 two-stage air compressor with integral control. Ratings of 300-350 hp.


NEW
COOPER-BESSEMER
DMR-2 TWO-STAGE
AIR COMPRESSOR
WITH
EN-TRONIC CONTRO
100 TO 250 HP

De Laval tackles process problems



...economically!

Continuous recovery of fine dispersion as slurry meant $$ in catalyst saving... and greater throughput

Problem: An expensive catalyst remained finely dispersed in the heavier of a two-phase reaction mixture. Previous recovery attempts gave a hard cake of non-dispersible catalyst.

Solution: The catalyst was discharged continuously from the centrifuge bowl wall as a re-useable concentrated liquid slurry in a De Laval AC-VO "Nozzle-Matic" Centrifuge.

Control of the slurry concentration was easily effected by recirculation of a portion to the feed stream. An ideal concentrated, dispersed slurry was thus obtained, suitable for re-use. Savings come not only from the recovery of valuable catalyst, but also from faster, continuous throughput of the entire product stream.

"Haze" removal and the separation of thick slurries are the extremes in solid-liquid and solid-liquid-liquid centrifugal separation. De Laval is unmatched in equipment and experience in this entire range. Try us!

For Further Information Write To Dept. C-8

DE LAVAL

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES

Remarkably small unit delivers 11,000,000 Btu/hr ...typifies new trend in heat exchanger selection

Every hour, 100,000 pounds of river feed water is heated from 40° to 150°F at Finch, Pruyn & Company, Glens Falls, N.Y. Waste sulfite liquor supplies the heat, and the exchange of 11,000,000 Btu hourly is done in a space 6'2" x 2'9" x 11'8"!

No other type of heat exchanger could have been put in this waste space. More important, the compact size makes stainless steel construction practical – a lifetime assurance of trouble-free operation. This application is typical of many in which De Laval Plate Heat Exchangers are replacing bulkier, less-efficient types.

An objective appraisal tells you why. Here are the up-to-date facts:

- De Laval Plate Heat Exchangers require only one-quarter the heat exchange surface of shell-and-tubes.
- This reduced exchange surface is arranged in a remarkably compact unit.
- With stainless-steel construction throughout, there is a "lifetime" pay-off in corrosion-free service.
- De Laval Plate Heat Exchangers clean in-place – or open quickly and easily for thorough scrubbing.
- Where needed, unusually stable temperature control is easily obtained.
- Sub-division of the exchange capacity –or expansion at any time – is easily effected by introducing additional heat transfer plates.

Collectively, these benefits add to a low *total* cost in installation and operation that has led to greatly broadened applications in recent years. Check, at no obligation, on the contributions their efficiency can make to your operation. De Laval Plate Heat Exchangers range in size from laboratory models to capacities of over 200,000 lbs./hr.

1960 ISN'T 1950...WHICH WASN'T 1940!

"Time creeps up—not only on us but also on the 'facts' we work with. Look squarely at the present and future in terms of unit design costs; labor and plant space have gone high—will go higher. Unlike 20 or even 10 years ago, installation of 'lowest cost' types of process equipment can seldom be justified. Real economy now lies more than ever in the savings of small-space, low-maintenance performance, minimum supervision and long life. A case in point is the growing use of De Laval stainless steel Plate Heat Exchangers such as the installation described above."

Fred Wheelwright, Industrial Sales Manager

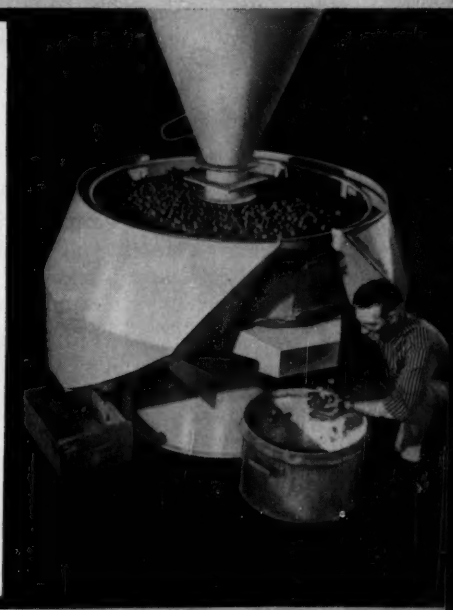
"3-D" winner in "shell game" also scores 95% in pearlite classification

Lumps, pellets, crystals or powders are kept hopping to a controlled frequency as they pass over or through De Laval's Syncro-Matic screen decks. Motion is fully "3-D" and is adjustable in each direction to suit the material and obtain the desired throughput and efficiency.

The result is unusually rapid and efficient classification. For example:

- A battery of six graders which separated walnuts to three standard sizes was down-grading 18 to 35% of them. A single De Laval Syncro-Matic Separator replaced all these machines and also reduced down-grading to under 1%! Throughput was 10,000 lbs./hr.
- Crushed pearlite ore required classification to four closely-defined grades. A single three-screen De Laval Syncro-Matic Separator processes 5 tons per hour to give better than 95% efficiencies in all four grades.

Maximum exposure of product to grading screens is provided in these Syncro-Matics. Available in single, double and triple screen decks, regular and stainless steel, they are certainly worth evaluating for both existing and planned classification installations. Write for information.



Recorders of the future will have

Powerful Servomatic Motors in both TRANSCOPE® Pneumatic and Electronic Recorders give unprecedented accuracy of records . . .

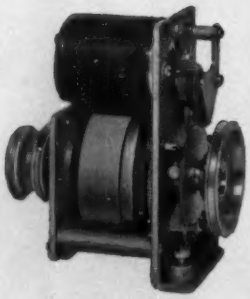
One of the reasons why the 90J (pneumatic) and 700J (electronic) recorders have become the most wanted miniature instruments is this exclusive Taylor feature . . . powerful Servomatic motors that give more precise pen positioning than ever before. Check these benefits:

- Threshold sensitivity of 0.1% to input signal.
- 150 times more power than bellows type used in conventional pneumatic recorders. Over 1,000 times the output power of galvanometer systems in electronic instruments.
- Unprecedented standards of accuracy—½ of 1% in standard instruments—¼ of 1% optional.
- 3 months' ink supply *mounted on the pen*—no capillary.
- Integral heavy duty process alarms in recorder cases . . . 2 per servo . . . up to 6 per recorder.
- No flimsy linkages and levers.
- Truly rectilinear chart—no curved time lines.

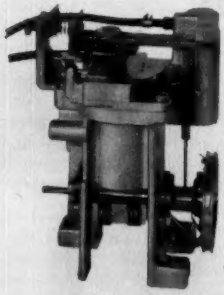
Servomatic motors also allow these optional features: alarm contacts; retransmitting potentiometer; function generation; digital output with encoder discs.

"Hunk of Brass" Test. Ask your Taylor Field Engineer to show you the 'Hunk of Brass' test — conclusive proof of the power of Servomatic motors to assure positive, precise positioning of the pen.

For full details of TRANSCOPE servo operated recorders and their many superior features, write for **Bulletin 98335** (electronic) or **Bulletin 98286** (pneumatic). Taylor Instrument Companies, Rochester, New York, and Toronto, Ontario.



700J (electronic) servo motor is 2 phase, size 15, 60 cycle, 117 volt—built to military specifications. Precision gearing couples the servo to a precise feed-back device with high torque.



90J (pneumatic) servo motor is essentially a power piston with a built-in positioner. Solid construction assures long, trouble-free life.

Taylor Instruments

Servo Power

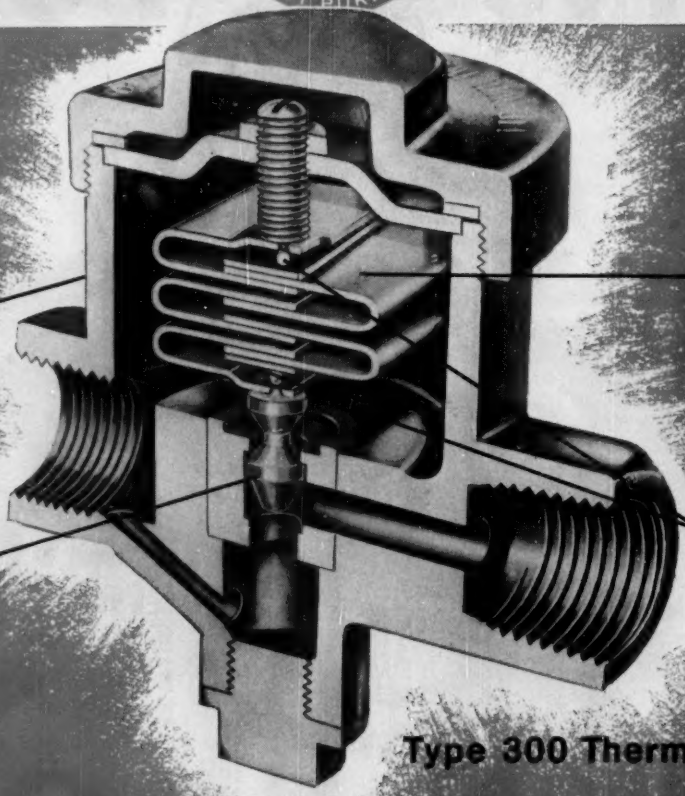
TRANSCOPE 700J
ELECTRONIC
RECORDER

...Taylor has it NOW!

MEAN ACCURACY FIRST

ONLY Farris MIL

PROGRESS THROUGH HONEST PURPOSE



FORGED MANGANESE BRONZE BODIES

Standard trap bodies (except the float models) are forged manganese bronze, selected for long life on steam. Aluminum bronze bodies also available.

HAND LAPPED PRESSURE BALANCED VALVES

Every Farris Mil valve is individually hand lapped to seat perfectly on the stainless steel insert. Valves are unaffected by pressure changes, respond only to temperature change.

INDESTRUCTIBLE BI-METAL

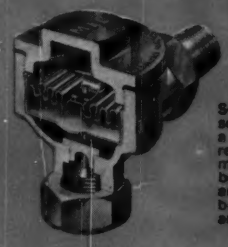
All Farris Mil trap bi-metallic thermal elements are high quality stainless steel. Cannot be damaged by water hammer, frost or corrosion. 2° sensitivity.

FRICTION-FREE FLOATING UNIVERSAL JOINTS

Bi-metallic element and valve cannot hang up or jam—no friction—no wear—no corrosion—no wire drawing—no maintenance.

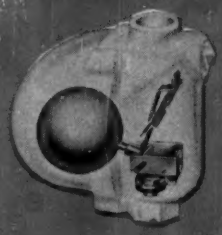
Type 300 Thermostatic

3 MODELS . . . 9 TYPES



SELF-ADJUSTING THERMOSTATIC

Self-Adjusting models are factory set to release water and air from a steam system as well as to release condensate at a predetermined temperature. Available in 4 body patterns in 25 psi, 65 psi and 125 psi ratings, forged bronze bodies, stainless steel element and valve, aluminum bronze seat.



FLOAT THERMOSTATIC

Float type Farris traps provide rapid high capacity venting of air and cold condensate at start-up. Unique rocker design gives high mechanical advantage. Body is hi-tensile iron, all mechanical parts stainless steel. Available in 75 psi and 150 psi ratings.

EFFICIENT TRAPPING DEPENDS ON THERMAL CHANGE! SAVE WITH MIL THERMOSTATIC TRAPS FOR ALL PLANT-WIDE SERVICE

SEND FOR NEW CATALOG

Free 8 page Farris Mil trap catalog #FE-310 gives complete dimensional data, performance information, and capacities for all 9 types.

PROGRESS THROUGH HONEST PURPOSE

Manufactured under patents, patents pending and licenses of Midland Industries Ltd., the largest producer of thermostatic steam traps in Europe.

ENGINEERING CORP.

MIL DIVISION

501 COMMERCIAL AVENUE • PALISADES PARK, N. J.

AFFILIATES:

Farris Flexible Valve Corp. • Farris Engineering Ltd., London, England • Farris Universal Machine Corp. • Farris Combustion Controls Corp. • Midland Industries Ltd., Wolverhampton, England

Palisades Park, N.J.

Houston, Texas

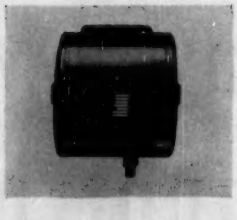
London, England

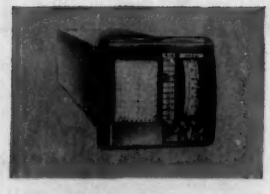
STEAM TRAPS

are indestructible ■ will not wire draw ■ will not freeze up ■ cannot be damaged by water hammer ■ do not need a cooling leg ■ cannot corrode ■ operate instantaneously ■ are pressure balanced ■ have full floating, friction free, self aligning, stainless steel valves ■ cost less ■ are guaranteed two years

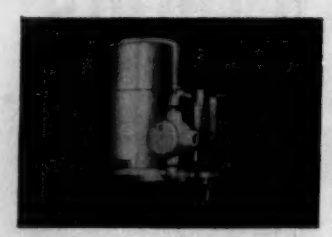
OVER A MILLION IN USE! TRY US—SEND YOUR ORDER FOR ONE OR MORE TRAPS. YOUR MONEY BACK IF THEY DO NOT PERFORM AS STATED!

ROBERTSHAW
MICROSEN





ROBERTSHAW + MICROSEN — NEW UNIFIED SOURCE



Everything's under Control!

Robertshaw + Microsen . . . new instrumentation source for precision control of pressure, temperature, differential pressure, oxygen concentration, liquid level, gas analysis, pH, flow . . . (Top, l. to r.) Microsen Transmitter, Microsen Recording Controller. (Bottom, l. to r.), Microsen Electro-Hydraulic Control Valve Operator, Level-Tek Level Detection and Control System.

FOR SUPERIOR PROCESS CONTROLS

Robertshaw—long a familiar name in capacitance - actuated level measurement instrumentation now provides industry with Microsen Electronic Controls —formerly manufactured by Manning, Maxwell & Moore, Inc.

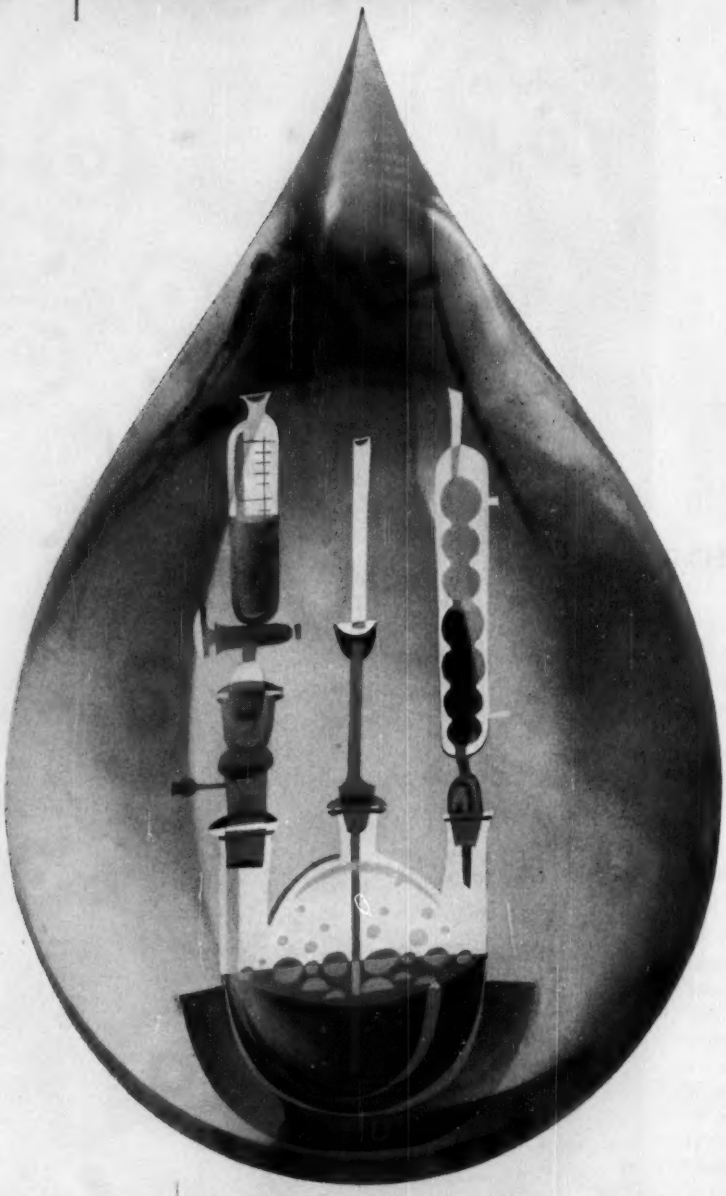
Now—one experienced source for more of your industrial process control systems.

Maximum automation can be applied to data acquisition, transmission, indication, recording and control of process variables. System flexibility assures low initial investment . . . system accuracy and reliability minimize operating costs. Truly helpful technical assistance from over 50 conveniently located offices in the Northern Hemisphere. Write for address of the one nearest you.

Robertshaw

Aeronautical and Instrument Division, Robertshaw-Fulton Controls Company, Santa Ana Freeway at Euclid Avenue, Anaheim, California

DOW | **BROMINE DEVELOPMENTS**



REACT FAST WITH BROMINE

Industry today is served by bromine and numerous brominated compounds in a multitude of chemical reactions that occur quickly and simply. Because bromine is highly reactive, it's extremely easy to add bromine onto a compound or take it off. And bromine frequently avoids undesirable side-reactions, unwanted by-products, and makes possible reactions at moderate temperatures and pressures.

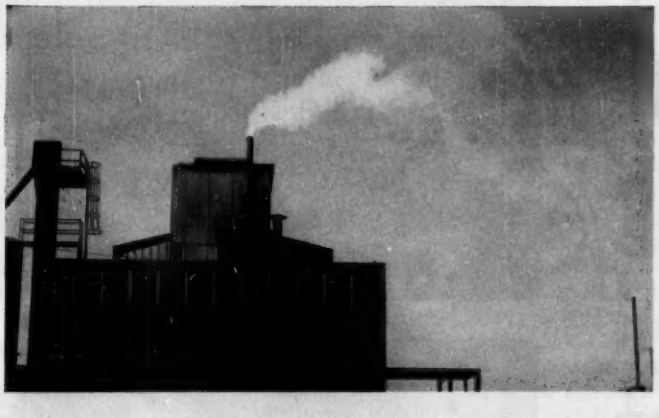
Every chemist can name a long list of examples. Even so, imaginative research continues to provide new brominated compounds for new uses as intermediates in both organic and inorganic chemistry. The result: new efficiency for old processes . . . and the creation of new processes. Brominated compounds are also attracting new attention for building dense fluids and for extinguishing fires.

Dow's first product nearly 70 years ago was bromine. Today, besides elemental bromine, Dow offers over 100 brominated compounds, with new ones constantly under study. Perhaps bromine or one of its many compounds can solve your problem. Dow has the facilities and experience . . . and the technical people who are eager to help you. For more information, write THE DOW CHEMICAL COMPANY Midland, Michigan, Chemicals Merchandising Dept. 652AK8-8.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Before scrubber was installed —visible cloud is composed largely of water with about 0.5% sulfur trioxide

THE CHEMICO VENTURI SCRUBBER MAKES THE BIG DIFFERENCE



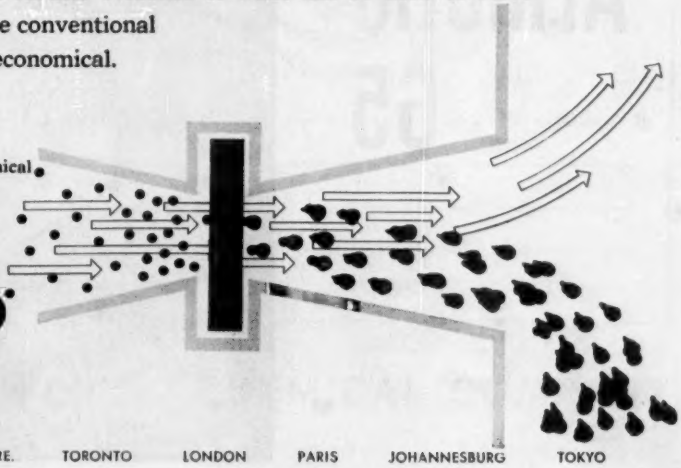
After scrubber was installed— water vapor has diminished considerably, sulfur trioxide content is practically nothing

With sulfur trioxide fumes being vented to the air in a thick vapor fog, Ansul Chemical faced an air pollution problem common to many chemical producers. They were willing and anxious to comply with community requests for pollution control, but they were unable to find a scrubber which could rid the stack of both the water vapor and the SO_3 as well.

While virtually any scrubbing device was capable of removing the water vapor, only the Venturi scrubber was effective in removing the acid fumes. By removing all but the last traces of SO_3 the Venturi scrubber gave further evidence of what can be done to solve really tough gas cleaning problems where conventional cleaning devices prove ineffective or uneconomical.

FULL DETAILS AVAILABLE

For your copy of a brochure giving complete data on Chemico Venturi gas scrubbers, or for technical assistance on a specific problem, write to Chemico at the address below.

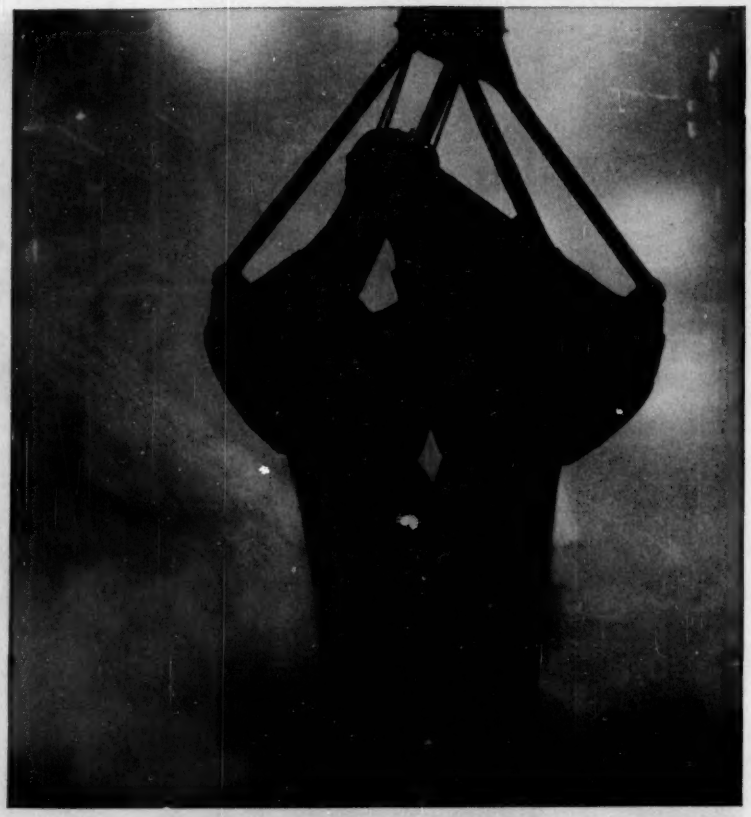


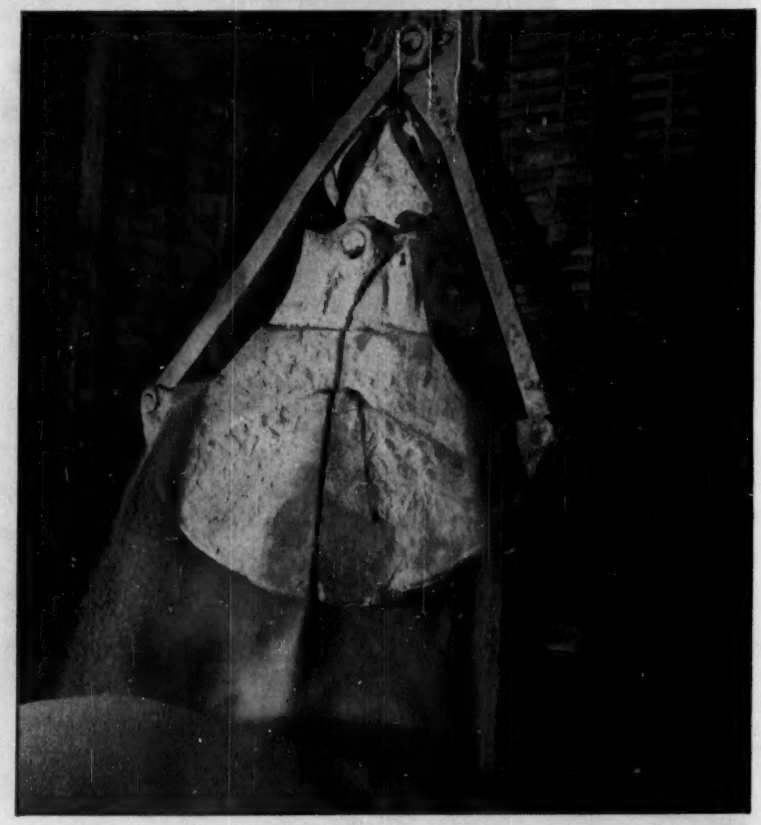
CHEMICO

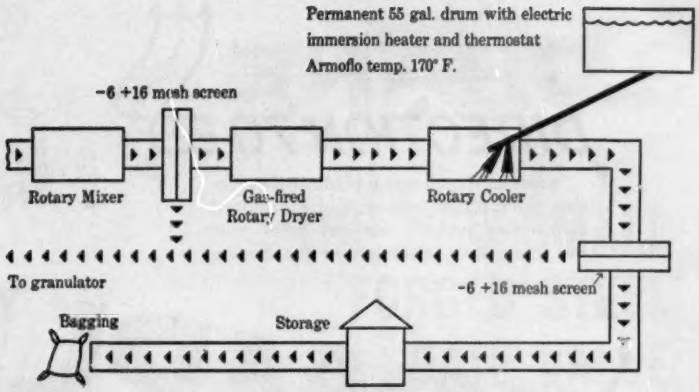
CHEMICAL CONSTRUCTION CORPORATION
Gas Scrubber Division
525 West 43rd Street, New York 36, New York

CHICAGO DALLAS HOUSTON PORTLAND, ORE. TORONTO LONDON PARIS JOHANNESBURG TOKYO

New cure for caking and dust problems: Armoflo 65







Dust is a common problem to all fertilizer manufacturers.

Now the Armour *Industrial* Chemical Company offers an effective solution with Armoflo 65 and other Armoflo formulations. Originally developed as cationic anti-caking agents for hygroscopic materials, these compounds display excellent dust control as well. The Jeffersonville, Indiana, plant of the Armour *Agricultural* Chemical Company has just completed the first season of production using Armoflo 65. W. C. Brodfuehrer, Plant Superintendent, summed up by observing, "I'd say there was an overall improvement of about 75%."

Results in Jeffersonville also show that caking is no longer a problem. To use the Armoflo formulations most effectively, personnel at Jeffersonville made minor revisions in the plant layout as illustrated in the flow diagram above and explained in the accompanying description.

Trade Name	MP°C Average	Recommended Anti-Caking Uses
Armoflo 65* (Cationic)	5°	• Hygroscopic Fertilizers and Salts • Sulfur • Thermosetting Plastics
Armoflo 66 (Cationic) (*New*)	34°	• Highly Hygroscopic Salts and Fertilizers
Armoflo 48* (*Anionic*) (*New*)	—3°	• Hygroscopic Sodium and Calcium Salts

*Also recommended for dust control

General Recommendations

Armoflos are preferably applied warm to hot—dripped, sprayed, or fogged—to materials in the range 100-250° F. Thorough mixing should follow, preferably in rolling equipment, to secure the hydrophobic monomolecular Armoflo layer which imparts protection against caking and to which fine dust particles adhere. Method of addition, for these Armoflos, is *as received.*

Plant Operation

Armour Agricultural Chemical Company
Jeffersonville, Indiana

The fertilizer base goods are fed into the granulation plant where they are intimately treated with water and liquid reactants. Screening is done next to avoid recoating the circulating load. The reaction mixture is then dried in a gas fired rotary dryer, and passed to a counter-current rotary cooler. The Armoflo, at 1#/T, is sprayed into the cooler through 2 nozzles at the point of air intake. Both sufficient heat to hold the Armoflo in a fluid, mobile state and proper mixing to insure thorough and complete spreading of the Armoflo are available at this point. The dryer exit or cooler entrance also would be satisfactory points of addition on the basis of these temperature and mix characteristics. The cooled fertilizer is screened to eliminate the undersize caused by attrition, and then the product is bagged for shipment.

We will be pleased to provide additional information and samples for your evaluation at your request.

PLEASE SEND ME

Armoflo Booklet.... ☐
Armoflo Samples 48 ☐ 65 ☐ 66 ☐

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE___ STATE____

CE-8-60

ARMOUR INDUSTRIAL CHEMICAL COMPANY

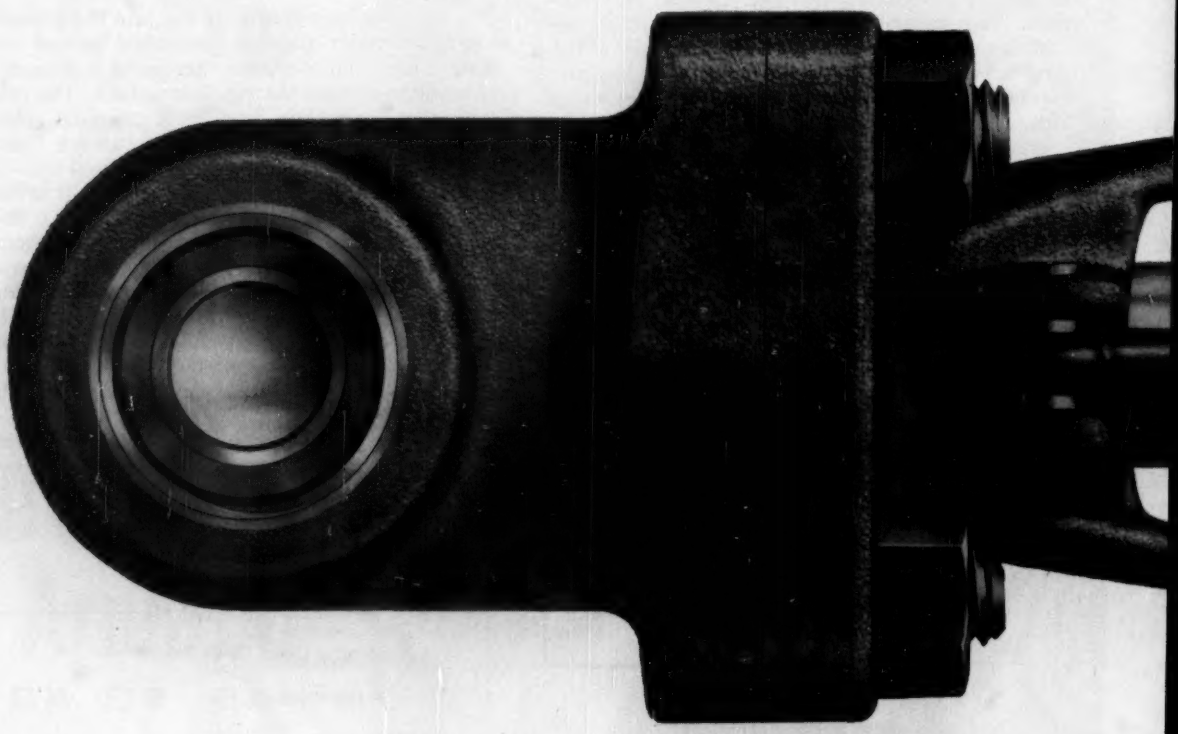
© Division of Armour and Company / *110 North Wacker Drive • Chicago 6, Illinois*

Reporting more news from...

CRANE
DIRECTION '70

...a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the competitive challenges of the Sixties.

COMPLETELY



REDESIGNED!

THE NEW SMALL FORGED STEEL GATE VALVE

NEW CRANE FORGED STEEL GATE VALVE
600 psi @ 900 F; 800 psi @ 850 F; 2000 psi WOG. Screwed Ends No. 3604 XU; Socket Welding Ends No. 3605 XU. Sizes ¼" through 2".

This is a whole new valve, not just one with a new feature added. This redesign incorporates all the features you told us you wanted plus a few others we know will make this valve a better buy in terms of longer service life, less maintenance, easier and faster servicing.

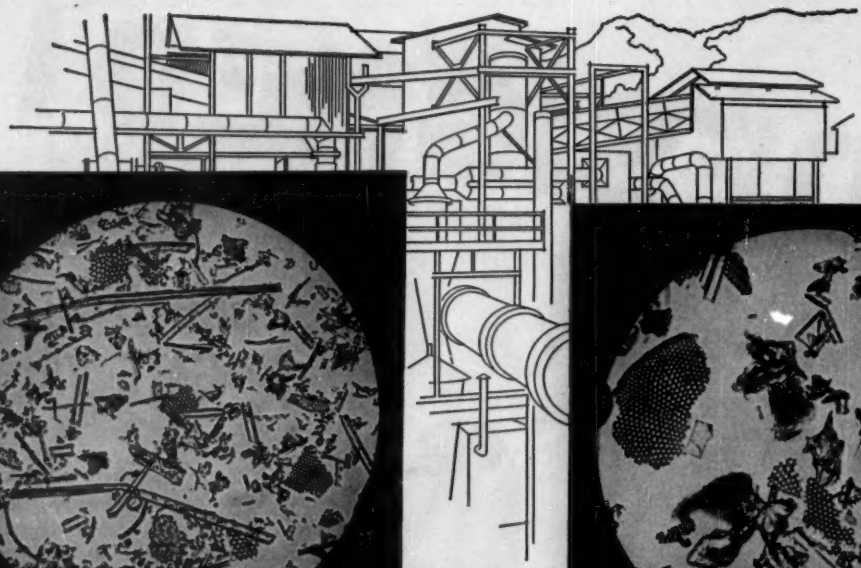
Like the new "bow-leg" yoke, which for the first time gives you plenty of hand room for easy stuffing box maintenance. And like the long-life braided asbestos packing, with Inconel wire insert. The "universal" trim that can be used for either oil or steam, eliminating many of your stocking problems. The spiral wound stainless steel bonnet gasket with asbestos filler, made blowout-proof with a male-female joint.

But what we really want you to remember, more than any single feature, is that this Crane valve is the newest—all new—valve on the market... well worth considering when you need small, high-pressure steel gate valves. We'd like you to compare this new valve with any other comparable valve feature for feature.

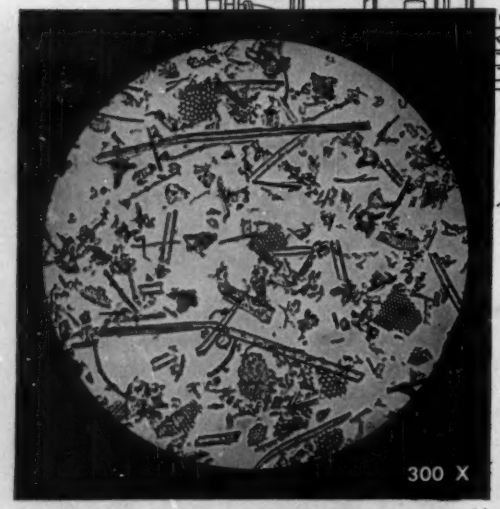
Your local Crane distributor has technical literature and a complete selection of these valves right in stock. Call him on small steel gates. In fact, he's your best bet to call no matter what valve you want because he carries the broadest line of quality valves in the world.

CRANE®

CRANE CO., INDUSTRIAL PRODUCTS GROUP
4100 S. KEDZIE AVE. • CHICAGO 32, ILL.
VALVES • ELECTRONIC CONTROLS • PIPING
PLUMBING • HEATING • AIR CONDITIONING



Milling and calcining equipment used for all Celite grades.

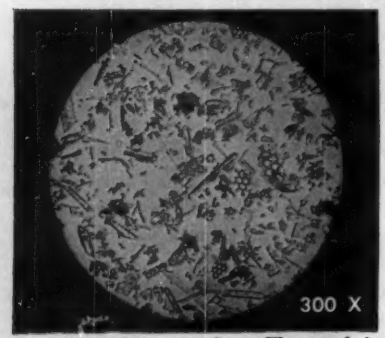


For high-clarity filtration of most liquids—use this specially milled diatomite, Hyflo Super Cel.

For filtration of larger suspended particles—Celite 545 combines maximum clarity plus faster flow rates.

In diatomites, Johns-Manville precision processing works for you

Constant uniformity in every grade of Celite assures consistent results, less down-time



For mineral filler use—Super Floss grade is made up of carefully sized fines air-floated off in the bag house.

Typical J-M bag house equipment.

As THE MICROSCOPE SHOWS, each grade of Celite* diatomite has its own distinctive particle size distribution. Yet no matter where or when purchased, each remains uniform from bag to bag—your assurance of top production results with minimum down-time.

Three examples of flux-calcined Celites are shown here. Hyflo® Super Cel is widely used for filtration in many industries. It has just the right combination of coarse and fine particles to assure optimum clarity and flow rates. Celite 545, with a higher percentage of coarse particles, is used to achieve maximum clarity and faster flow rates with liquids that have larger suspended particles.

Super Floss, one of several bag house grades, has fine particle size distribution. A white powder, it is processed within very narrow tolerances (less than 1% retained on 325 mesh). It is a popular filler in fine products such as silver polishes.

Johns-Manville can precision-produce so many different grades of Celite because it mines the material from the world's largest and purest commercially available deposit. For assistance with specific filtration or mineral filler problems, talk to a nearby Celite engineer. Or write direct to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

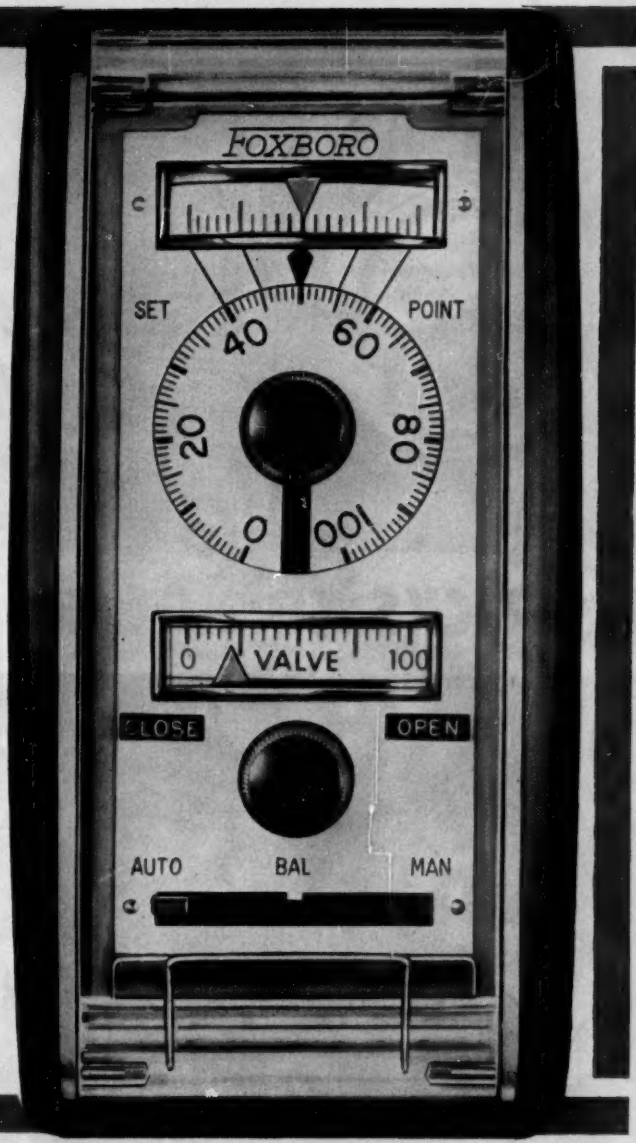
JOHNS-MANVILLE

Measurement deviation...

plus indication...

plus valve position...

you get them all with this **Foxboro electronic control station**



Shown here actual size →

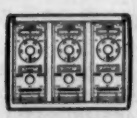
One 3" x 6" panel station containing all control and supervisory functions — that's the Foxboro Electronic Consotrol* Controller. All d-c input — all d-c output — all solid state. Operates completely independent from recording.

And look at these other features:

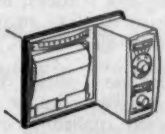
- measurement and deviation indicator gives continuous indication of process measurement as well as showing the deviation from set point.
- calibrated set point dial, with 4¾" scale, used with deviation indicator for readability of ½% full scale.
- valve position indicator for continuous, horizontal-scale indication of valve opening.
- simple auto-manual transfer switch for smooth, bumpless transfer.

Foxboro electronic Consotrol control stations are available for cascade, ratio and auto-selector systems. Ask your Foxboro Field Engineer about them — or write for **Bulletin 21-10. The Foxboro Company, 368 Neponset Avenue, Foxboro, Massachusetts.**

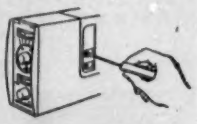
Reg. U. S. Pat. Off.



Standard 9" x 6" housing holds 3 control stations, or 1 station with a companion recorder.

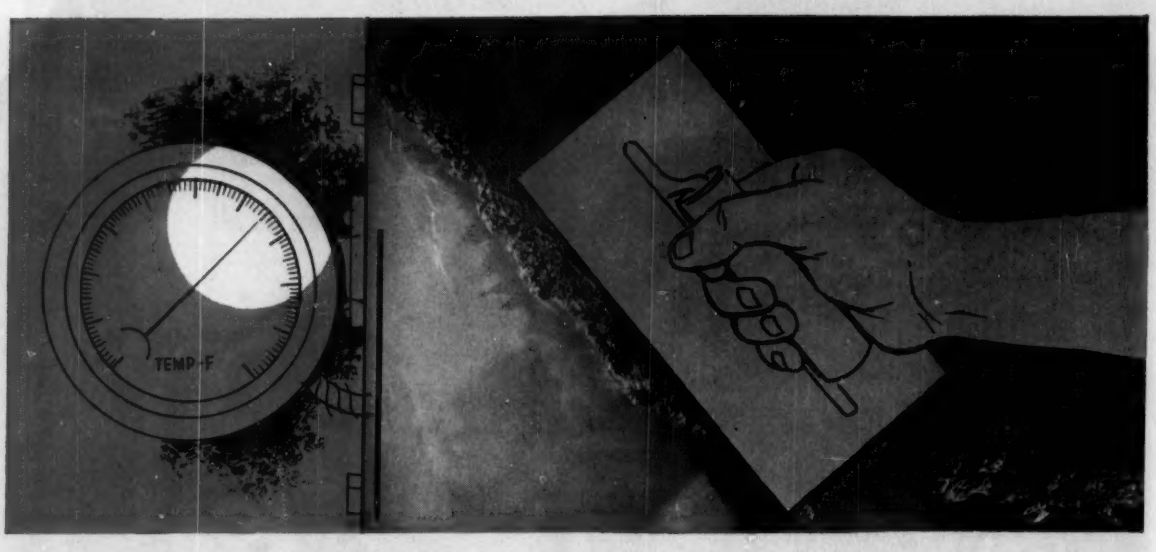


Controller and recorder each slide out from panel for easy servicing.

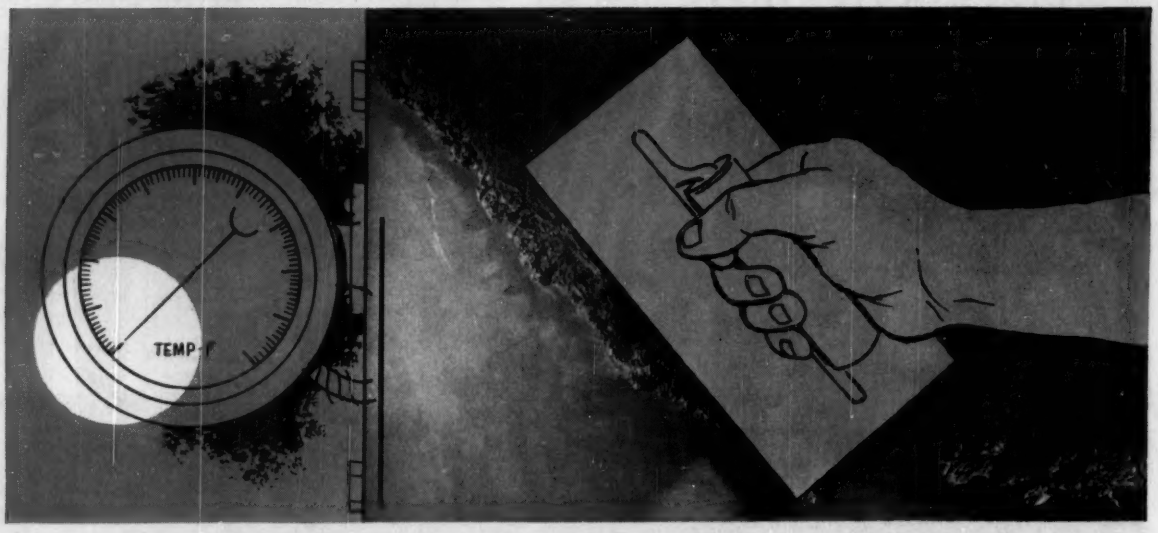


Proportional — reset — derivative: all adjusted from the front.

FOXBORO
REG. U.S. PAT. OFF.



IT STICKS TO HOT OR COLD SURFACES!



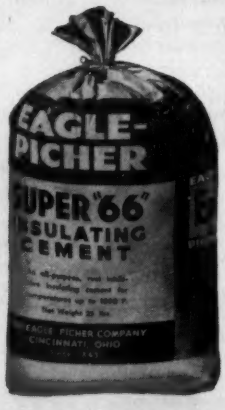
EAGLE-PICHER
SUPER "66"
INSULATING CEMENT

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

EAGLE EP PICHER

Since 1843

The Eagle-Picher Company
Dept. CE 88
General Offices: Cincinnati 1, Ohio

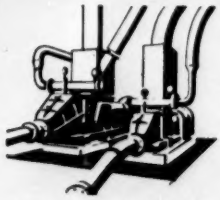


Here's why you save money when you use Eagle-Picher Super "66" Insulating Cement

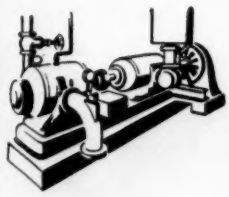
- Because it sticks, Super "66" saves time — applies quickly to any equipment, cold or hot. Effective up to 1800°F. . . . and it contains a special rust inhibitive which actually prevents corrosion !
- Because it sticks, Super "66" saves money— provides far greater coverage and more efficient insulation.
- Because it sticks, Super "66" makes difficult jobs easy—can be used on irregular shapes where application of other insulations is often impossible. Usually requires no reinforcing on applications up to 1½ inches thick.

FULLER EQUIPMENT

for the process industries

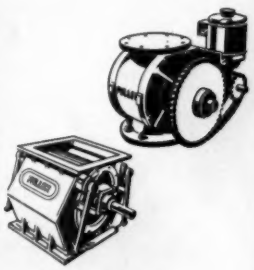


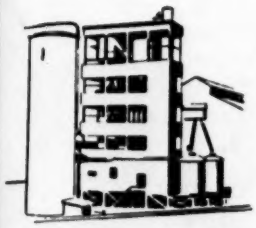
Pneumatic Materials Handling Systems. Widely specified throughout the process industries, Fuller's range of equipment offers best single source for solving problems in moving dry bulk materials pneumatically. Fuller-Kinyon Pumping Systems, Airveyor® Pressure and Vacuum Conveying Systems, and F-H Airslide® Fluidizing Conveyors are completely sealed to prevent both contamination of the product and any leakage of dust, etc., into the surrounding area. They are used to move dry, granular and pulverized materials to and from cars, ships, trailers, storage and processing points.



Fuller Rotary Compressors and Vacuum Pumps are vibration-free, can be installed anywhere, even on balconies. Fewer moving parts mean minimum maintenance. Compressors and Vacuum Pumps handle air and gases from 30 to 3300 cfm at pressures to 125 lb. gage. Vacuums to 29.95 in. (referred to 30-in. barometer).

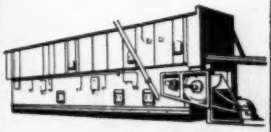
Fuller Vane-type and Roll Feeders . . . for volumetrically controlled feeding of a wide range of dry pulverized or granular materials. Also Fuller Rotary Valves . . . used under silo deck slabs and bins to permit the free flow of pulverized materials which tend to arch, such as lime and cement raw materials.





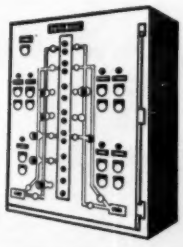
Fuller Preheaters, Humboldt Suspension Type . . . for preheating dry, pulverized Portland cement raw materials with rotary kiln waste gases.

Fuller Horizontal and Inclined Grate Coolers are compact, easily installed for fast, efficient cooling of materials such as nodulized phosphate rock, pebble lime, ores, dolomite, iron nodules and Portland cement clinker from 2800°F. or higher to any desired point within a reasonable range of atmospheric temperature.



Fuller-Material-Level Indicators signal audibly and visibly when materials reach a predetermined high or low level. Controls conveyor motors, valve circuits, etc.

Fuller Control Panels permit automatic, remote, one-man control of multiple operations. Easily-read panel permits visualizing flow of material to storage or from process bins.



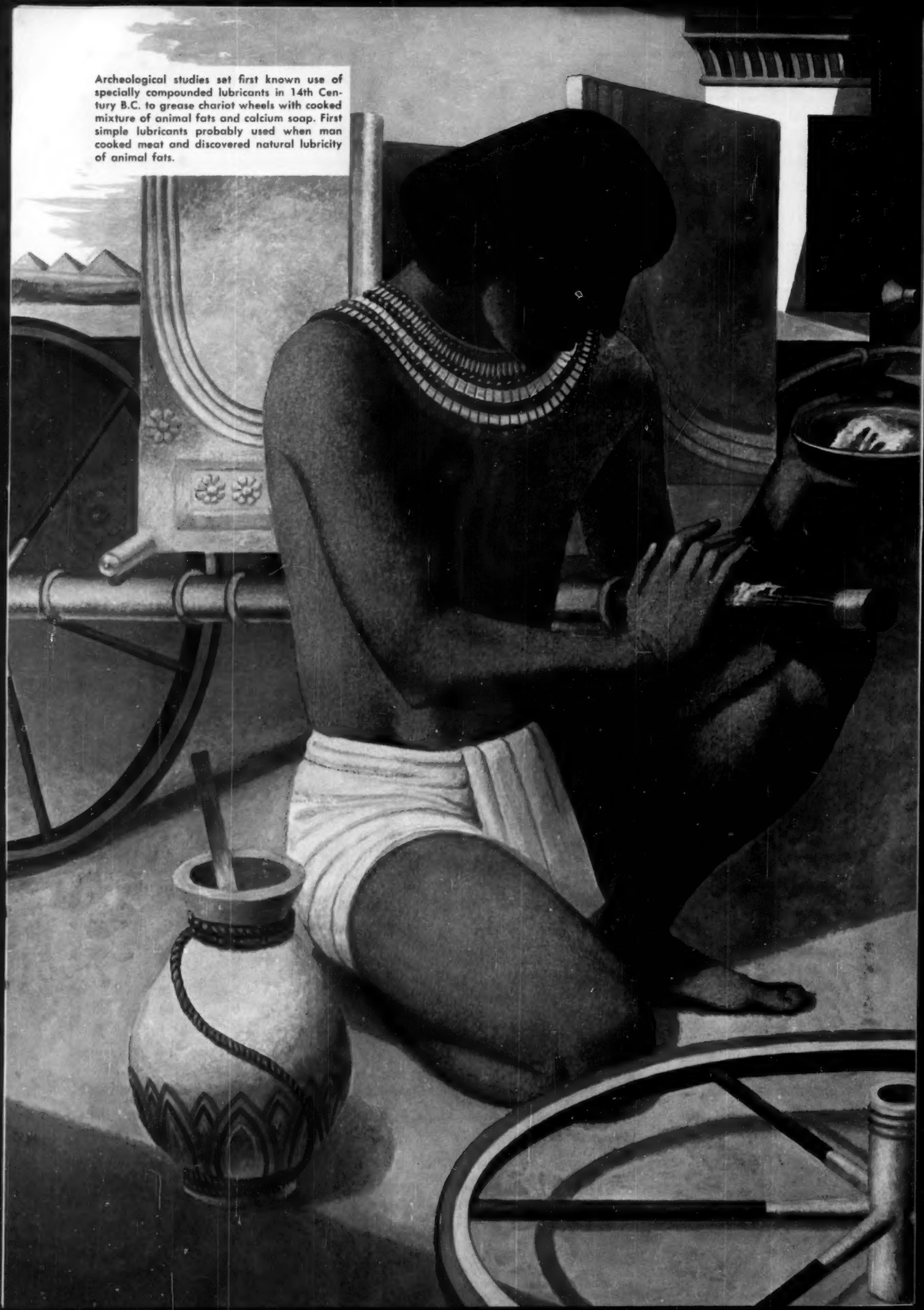
Fuller equipment is designed to help give you maximum efficiency at minimum cost. Send today for more detailed literature.

1356
G-210

For details on Fuller Product Line see Chemical Engineering Catalog

FULLER COMPANY
134 Bridge St., Catasauqua, Pa.
Subsidiary of General American Transportation Corporation
OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

Fuller
pioneers in harnessing AIR



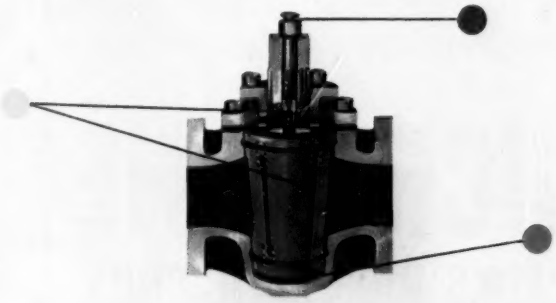
Archeological studies set first known use of specially compounded lubricants in 14th Century B.C. to grease chariot wheels with cooked mixture of animal fats and calcium soap. First simple lubricants probably used when man cooked meat and discovered natural lubricity of animal fats.

he greased the wheel of progress

. . . and his idea helped give you a better valve

One day about thirty centuries ago an ingenious charioteer silenced a squeaky chariot wheel with a handful of grease. To his surprise, the wheel not only ran quietly, but easier. Man had learned that lubrication makes things work better . . . and last longer.

Lubrication in Rockwell-Nordstrom lubricated plug valves does more than make them close easier and far outlast non-lubricated valves. *Pressurized* lubrication also hydraulically jacks the plug minutely from its seat, insuring easy operation and also maintaining a powerful seal against leakage around the plug . . . a seal that is instantly replaceable and can't be "worn out" like exposed metal-to-metal seats. For just a few of the reasons why you'll get better flow control at far lower cost with Rockwell-Nordstrom lubricated plug valves, examine the illustration below.



HOW LUBRICATION MAKES A BETTER VALVE

- Lubricant quickly, easily injected through Rockwell fitting.
- Lubricant travels through Sealdport® system to create powerful seals against leakage and prevent metal-to-metal wear between plug and body . . . note seats never exposed to the line.
- Lubricant hydraulically jacks plug minutely from seat for instant quarter-turn operation.

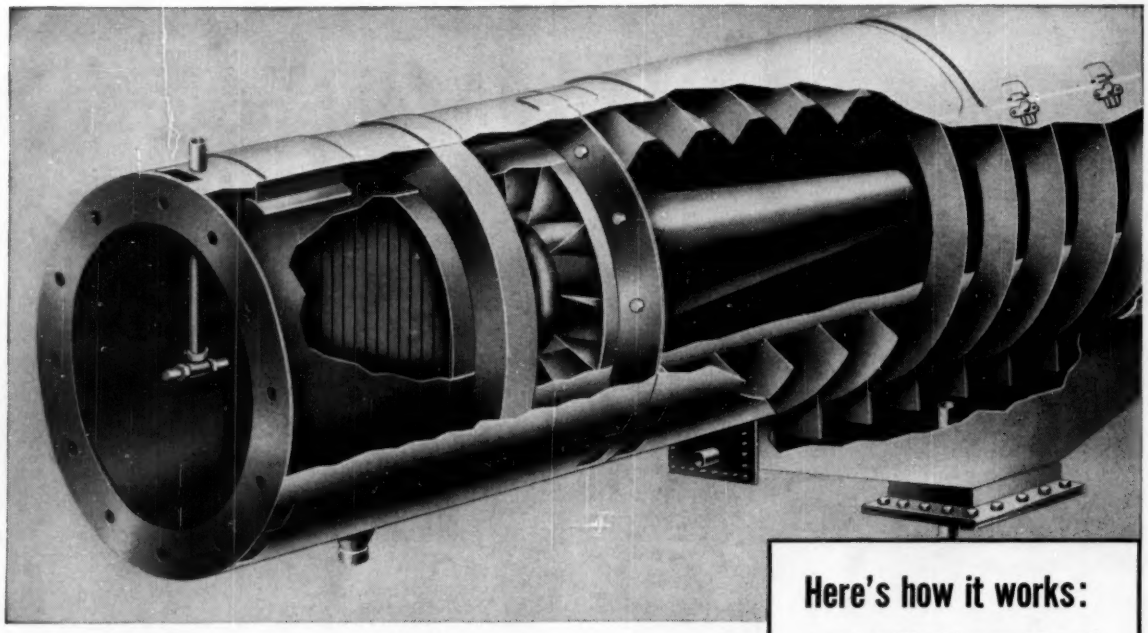
Rockwell-Nordstrom is the original and world's most complete line of lubricated plug valves. Available in sizes from ½" to 36" and pressures to 15,000 lb. For additional information, see your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania. Canadian Valve Licensee: Peacock Brothers Limited. If you live outside the USA, write: Rockwell International S.A., Geneva, Switzerland.

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL



The Western Precipitation

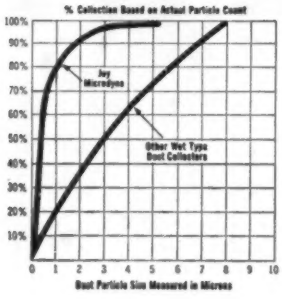
JOY MICRODYNE®

SCRUBBER PACKS HIGH EFFICIENCY IN 1/10 THE SPACE

Here's how it works:

a spray of liquid enters the collector along with the dust. An impingement screen helps to encase each particle with liquid. Then fixed vanes impart a whirling motion to the wet, dust laden air. Moisture and dust particles are thrown to the sides by centrifugal force and drain into a sump.

The liquid used may be water, oil or solvents, depending on the material being collected.



By combining two proved principles of dust collection, the Joy Microdyne collects over 99% by weight of dust particles 5 microns and larger; 92% of 2-micron dust. This means cleaner air.

Because of its unique design the Joy Microdyne is extremely compact . . . 1/10 to 1/20 the size of conventional wet collectors. For example: an 8000 cfm unit is only 26″ in diameter, 130″ long. This means lower initial cost and easier installation . . . in fact, the Joy Microdyne can be installed as part of existing ductwork.

The Joy Microdyne Scrubber is another in the wide range of dust collection equipment offered by Western Precipitation—by far the most complete line in the industry. *Write for descriptive literature!*

WESTERN
PRECIPITATION
DIVISION OF JOY MANUFACTURING COMPANY
1000 WEST 9TH STREET, LOS ANGELES 54, CALIFORNIA
NEW YORK 17 • CHICAGO 2 • PITTSBURGH 2 • ATLANTA 5 • SAN FRANCISCO 4

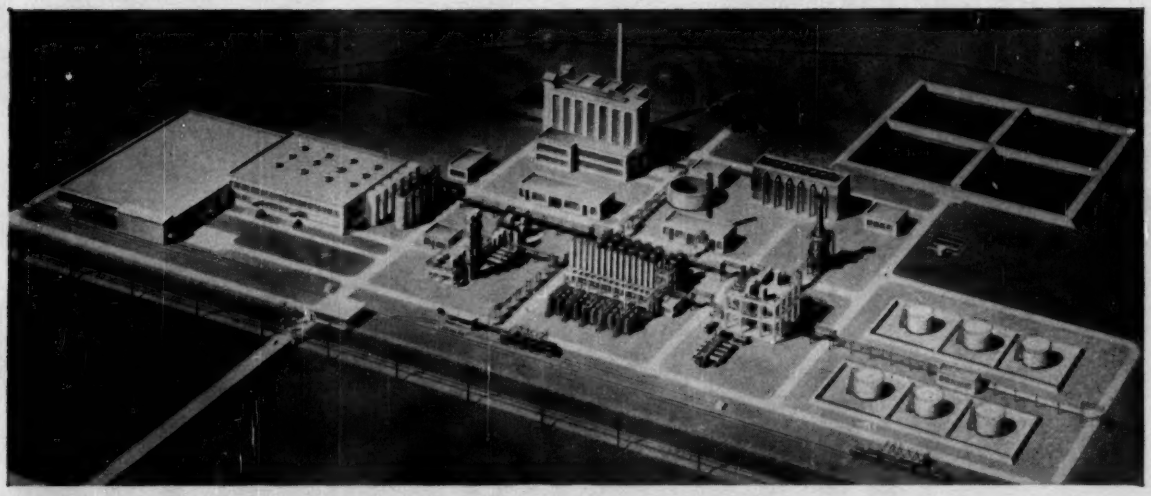
Cottrell Precipitators	Multiclone Dust Collectors	Therm-O-Flex Hi-Temp Filters	Dualaire Reverse-Jet Filters	Turbulaire-Doyle Scrubbers	Joy Microdyne Scrubbers	Combination Units	Holo-Flite Processors	Hi-Turbiant Heaters

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

INDIA'S FIRST SYNTHETIC RUBBER PLANT SET FOR SYNTHETICS AND CHEMICALS, LTD.

Lummus to Design, Engineer and Construct 30,000 Ton Per Year Plant Near Bareilly, India



The Lummus Company has been awarded the contract to design, engineer and construct a 30,000 ton per year synthetic rubber plant near Bareilly, Uttar Pradesh, India for Synthetics and Chemicals, Ltd. This firm was recently formed by The Firestone Tire & Rubber Company in association with the banking and industrial firm of Kilachand Devchand and Company Private, Ltd. of Bombay.

The 30 million dollar project will include plants for the production of butadiene and styrene, the principal raw materials, as well as a copolymer plant to manufacture the final product, synthetic rubber. In addition, Lummus will construct all the plant utilities and offsites. Although Lummus will design the plant for a capacity of 30,000 tons or more per year, the initial annual production will be 20,000 tons. Technical divisions of The Firestone Tire & Rubber Company are furnishing the basic engineering and know-how for the butadiene, styrene and copolymer units.

The plant site has been established in the heart of the sugar cane and alcohol producing area, and the alcohol obtained from the sugar cane will be the source of the butadiene, the principal ingredient of synthetic rubber.

Indian technicians and operating personnel will be trained to run the plant, whose final products will meet standard world-wide industry specifications.

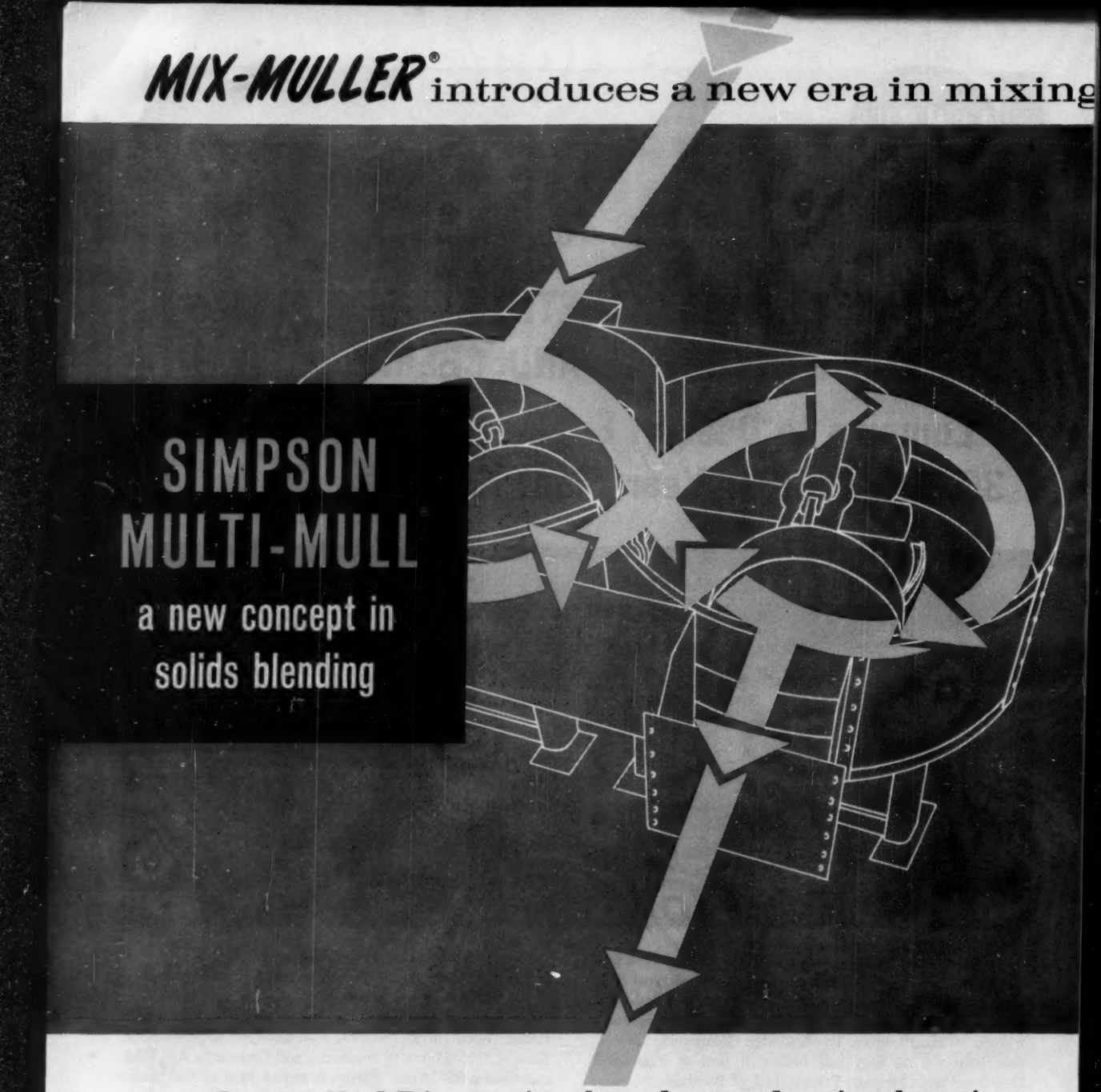
Financing of the project will be assisted by a 27,100,000 Indian rupee (or $5,700,000) loan from the Export-Import Bank of Washington to Synthetics and Chemicals, Ltd. This constitutes the largest foreign currency loan in the bank's history. The remainder of the financing will come from private banks in the United States and the United Kingdom as well as from India.

The project is expected to save India approximately 10 million dollars in foreign exchange annually.

Lummus has over 50 years' experience in the design and construction of more than 850 plants for the process industries throughout the world. Call Lummus on your next project.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Engineering Development center: Newark, N. J.

MIX-MULLER® introduces a new era in mixing



SIMPSON MULTI-MULL

a new concept in solids blending

Controlled Dispersion breaks production barriers

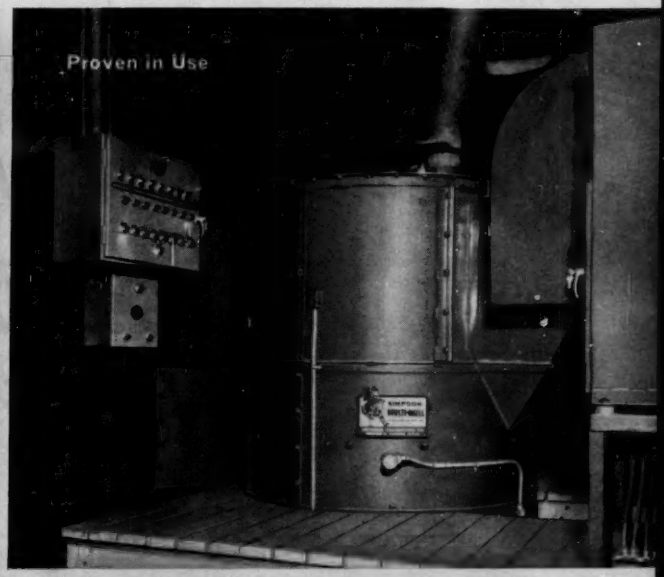
The era of continuous mulling is here, now. The new Simpson *Multi-Mull* is specifically designed to deliver the quality of prepared material, which can be achieved only through mulling . . . in continuous high production quantities.

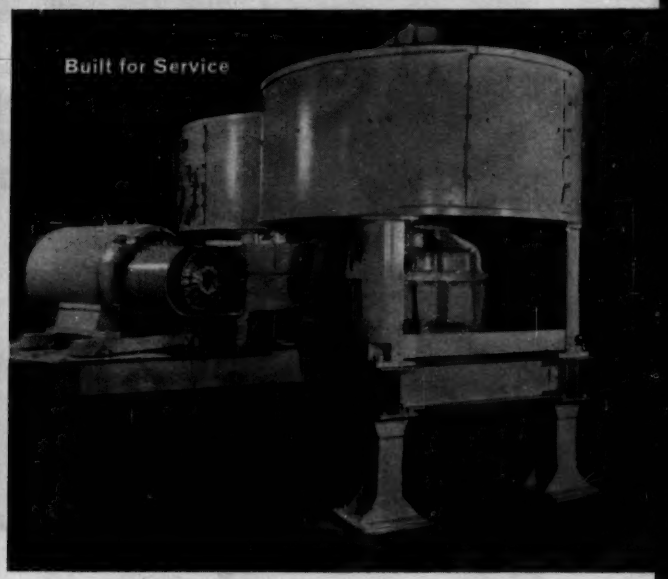
This means that many processors can take advantage of the benefits of controlled dispersion for the first time. It also means that many muller users can look forward to greatly increased mixing capacity and the elimination of many labor and equipment problems involved with batch-type operations.

No cure-all, *Multi-Mull* is being introduced to do *certain* mixing jobs better and faster than they have ever been done before . . . under a performance guarantee*. A full line of models ranging in pan retention capacities of from 6 to over 120 cu. ft. is available.

A new bulletin describes *Multi-Mull*. Write for your copy.

with a full line of CONTINUOUS MULLERS





Advantages: Continuous Controlled Dispersion:

• No need for batch accumulating or storage components • Large capacity in small floor space • Absolute moisture control • Little operator attention • Only equipment of its type available • Mix-Muller quality—in continuous quantities • Low equipment cost per ton of prepared material • Backed by performance guarantee • Handles: solid/solids, dry/solids, wetted/solids

Write for Literature

Nothing Mulls Like a MULLER

120

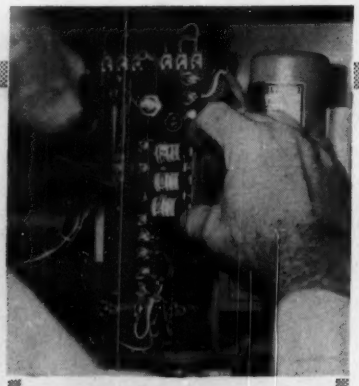
***Multi-Mull Performance Guarantee . . .** we will test the mulling characteristics of your material in a pilot unit. When you are satisfied with the quality of prepared material, we will specify equipment to match your production requirements. National Engineering Company will then build it, install it and not leave your plant until Multi-Mull satisfies the terms of the mutual agreement.

The Multi-Mull will not be sold upon the basis of unqualified production or performance claims.

SIMPSON *MIX-MULLER*® DIVISION
NATIONAL ENGINEERING COMPANY
636 Machinery Hall Bldg., Chicago 6, Illinois

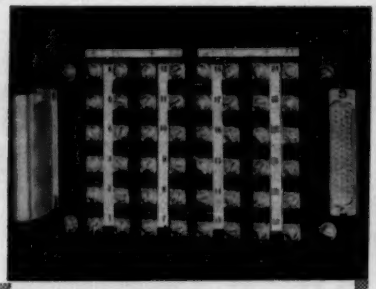
Record 2 to 24 points on the same

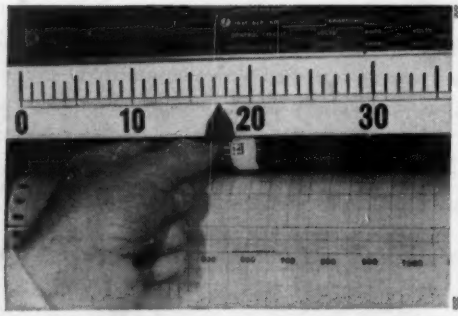
UNIVERSAL *Electronik* RECORDER



CHANGING RANGE IS EASY—Loosen screws and slide out the range resistor card. Replace with a different card, tighten screws and the job is done quickly and easily.

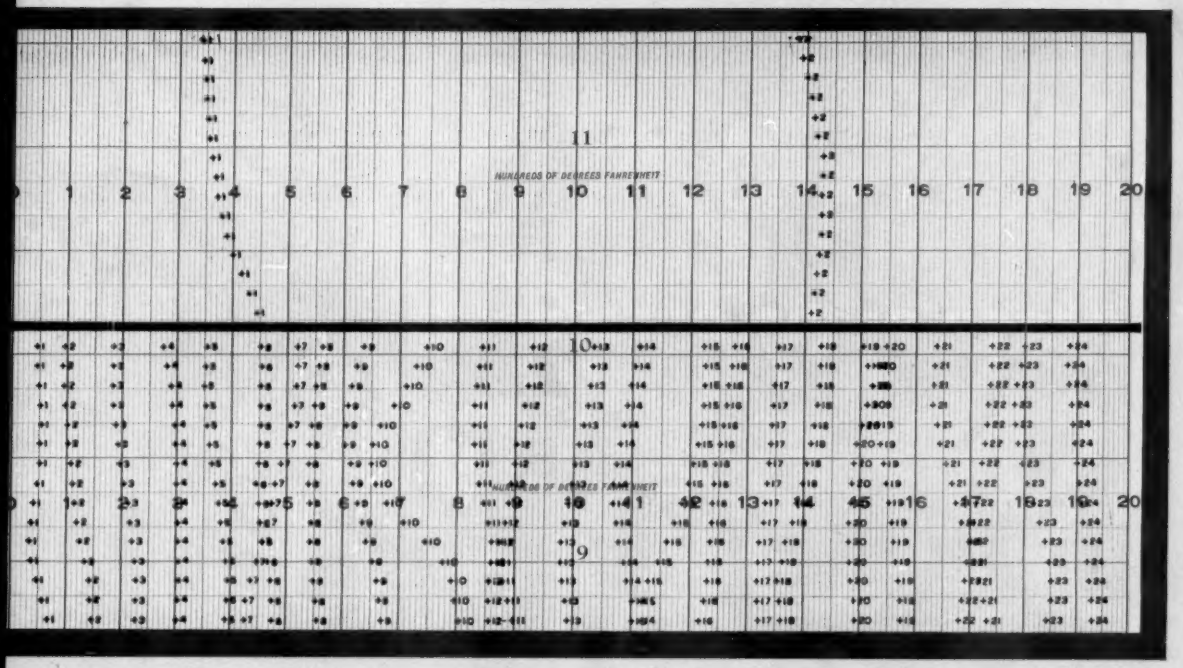
New modular design . . . and greater value than ever





CHANGING NUMBER OF POINTS IS EASY—First, remove thumb-tight nut; slip off print wheel and indicator dial. Slip on new wheel and dial and replace nut. Second, replace one plug-in unit on extreme right of terminal board, and the instrument is ready to record any desired number of points.

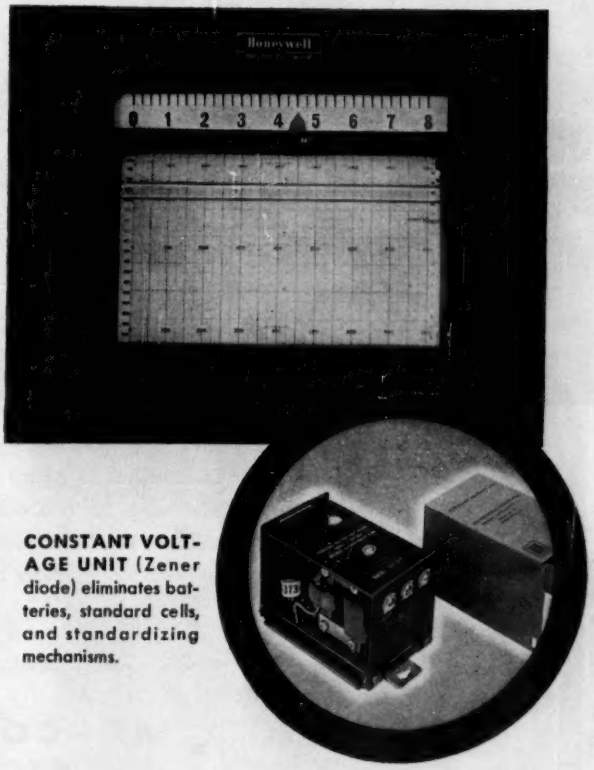
CHANGING COMPENSATION IS EASY—Input terminal board comes out by removing one plug (extreme left) and four screws. Slide in the new board, replace the screws and plug and the compensation is changed. Reference junction is built into terminal board on reverse side.



Now, you can record 2,3,4,6,8,10,12,16,20 or 24 points on one instrument—the new Universal *ElectroniK* Recorder. And you can change the number of points to be recorded in a matter of seconds. It's as easy as this: remove a thumb-tight nut and slip off the old print wheel and indicator dial. Slip on a new wheel and dial and replace the nut. Plug in the number of points wanted, and the job is done.

New modular design makes all *ElectroniK* instruments easier to use and maintain and a greater value than ever. This new design has also resulted in substantial manufacturing economies and appropriate price reductions. Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.



CONSTANT VOLTAGE UNIT (Zener diode) eliminates batteries, standard cells, and standardizing mechanisms.

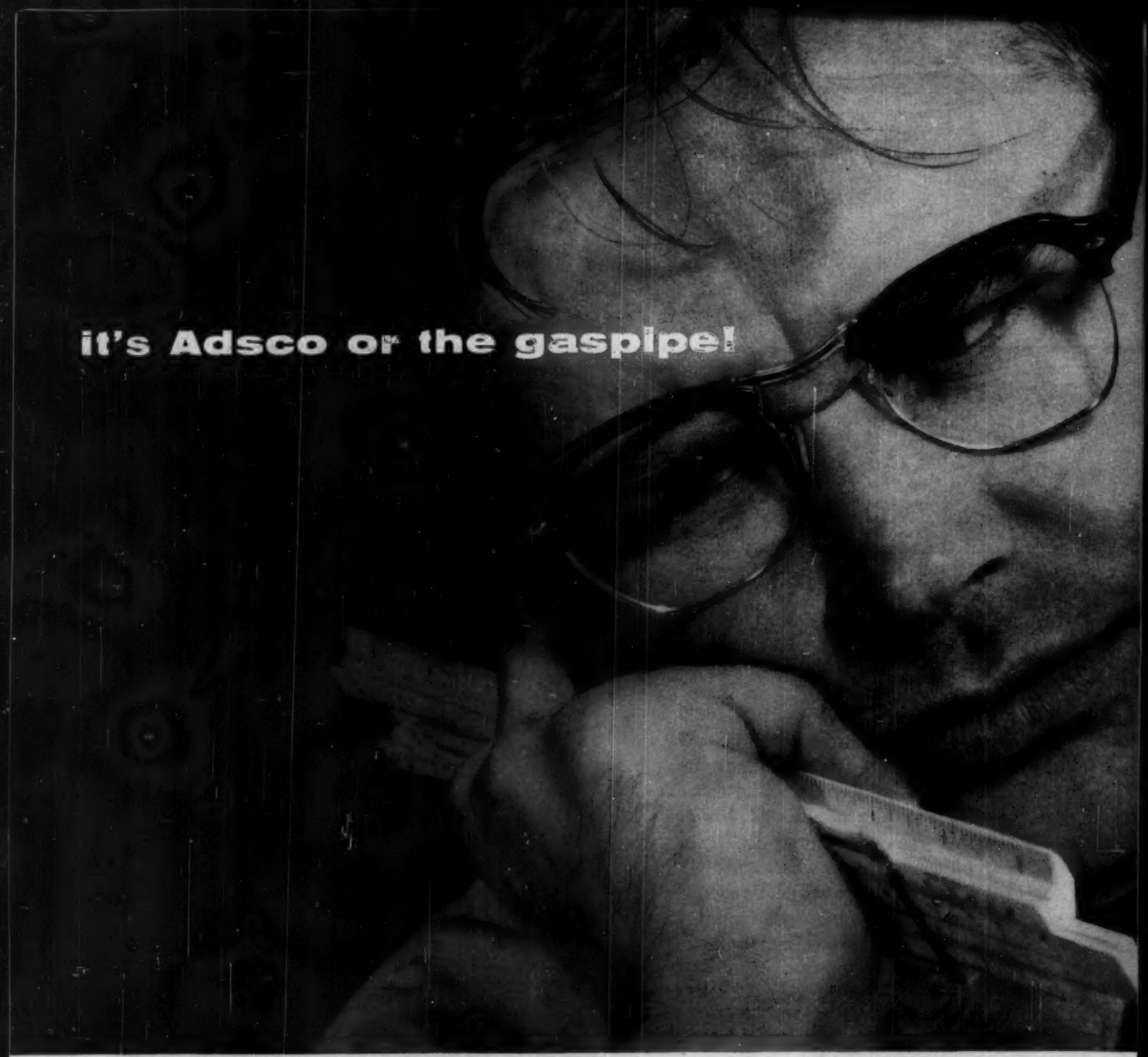
Honeywell

First in Control

SINCE 1885

75th YEAR

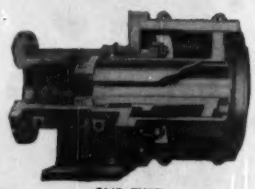
PIONEERING THE FUTURE



ONLY ADSCO HAS ALL 3 TYPES OF EXPANSION JOINTS

CORRUFLEX PACKLESS

RAM-PAK



SLIP TYPE

Choose Adsco, by all means. An Adsco man is no farther away than your telephone. He's a calm, cool and collected fellow who can straighten out any expansion problem in your piping system. He loves to be asked . . . call him quick, man, before it's too late!

Write for comprehensive catalogs

ADSCO ENGINEERED PRODUCTS

Sold, Engineered and Manufactured by

YUBA HEAT TRANSFER DIVISION

HONESDALE, PA.

World's Oldest and Largest Manufacturer of Packed and Packless Expansion Joints

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.

YUBA — A growth corporation serving growth industries

chemical
petroleum
steam—electric
hydro—electric
aeronautics
construction
heating
air-conditioning
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Anhydrous Ammonia
Brine
Caustic Catalyst
Caustic, 50% Solution
CO_2, Liquid
Diethylene Glycol
Di-propargyl Ether
Hydrocarbons

WHAT CHEMICALS ARE GIVING YOU PUMPING PROBLEMS?

Methanol Amine
Naphtha @ 300° F
Nickel Catalyst Slurry
Nitric Acid
Pulp Density Mineral Ore
Silica Gel
Slurry
Sulfuric Acid
Tanning Solution
Urea
Water

Where the pressures are high . . . or the liquids are tough to handle . . . that's for us!

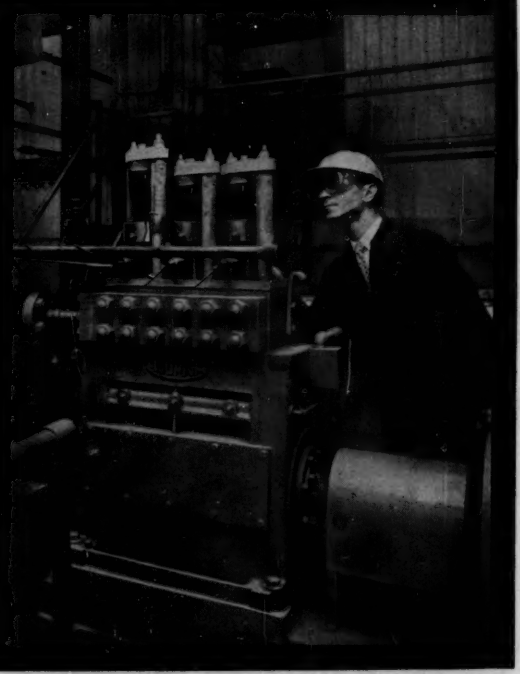
The list above is typical of the special pumping problems we have solved for the process industries . . . problems that call for an intimate knowledge of what it takes to handle corrosive, viscous, abrasive or highly compressible fluids over a wide range of pressures and temperatures.

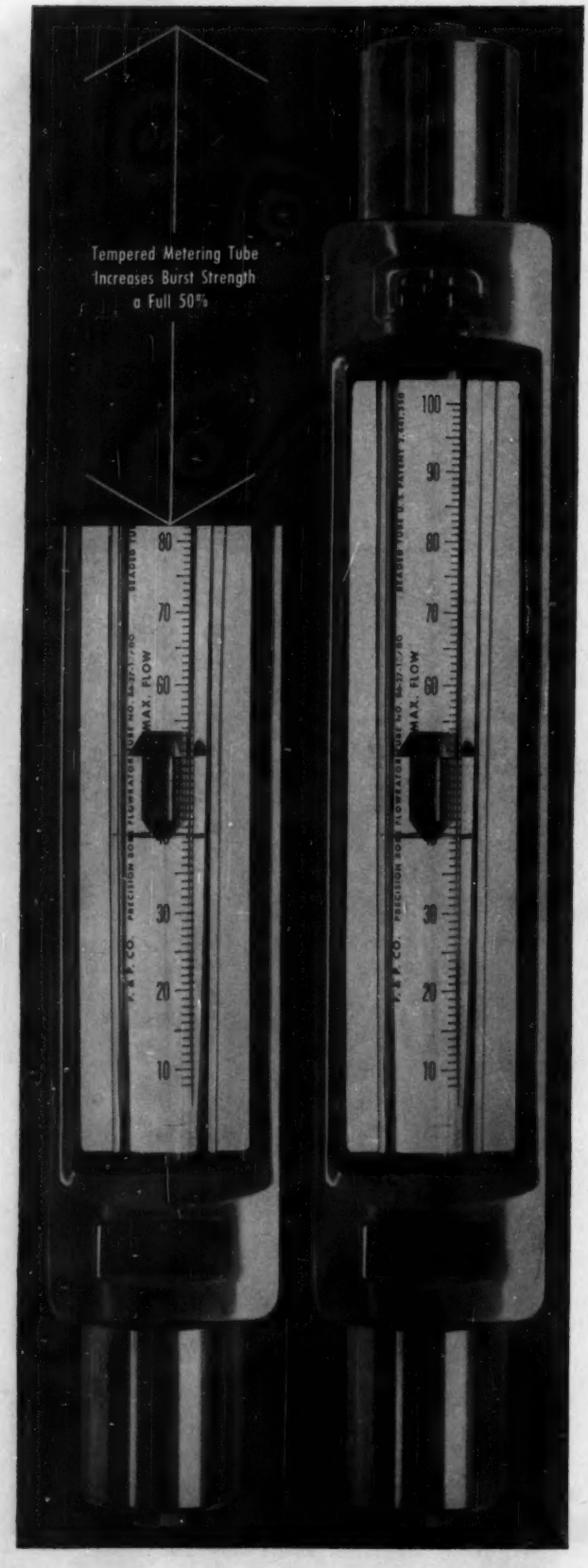
This specialized experience is ready to work on your specific pumping problems . . . to explore them in depth and find a *better* answer, not just *an* answer.

Aldrich Pumps range from 25 to 2500 hp.; pressures to 50,000 psi. For fast reference see our insert in *Chemical Engineering Catalog*. For complete data write ALDRICH PUMP COMPANY, 3 Gordon Street, Allentown, Penna.

The tough pumping problems go to

ALDRICH





New Rotameters Take 50% Higher Operating Pressures

Now, you can use glass tube rotameters where you've never dared use them before. New tempered glass metering tubes take up to 50% higher operating pressures. Install them with complete assurance on process lines that formerly required metal tube meters. And gain a desirable extra margin of safety *wherever* rotameters are used.

How F&P did it

This major advance in flowmetering art developed from two well known facts:

1. Glass has ten to twenty times more compressive strength than tensile strength.
2. Endwise pressure and uneven peripheral compression (as from a stuffing box) impart a substantial tensile component.

First F&P eliminated that tensile component by developing the unique O-ring "floating tube" seal introduced in the 2700 Series flowmeter.

Now, F&P has developed a special method of tempering the precision borosilicate metering tube that boosts compressive strength *without causing distortion!*

Be sure you get a tempered metering tube

Tempered borosilicate metering tubes are now being supplied as standard equipment with all Series 2700 flowmeters at no additional cost. But you *must* specify this make and series to enjoy the increased pressure rating.

Get complete information...Now

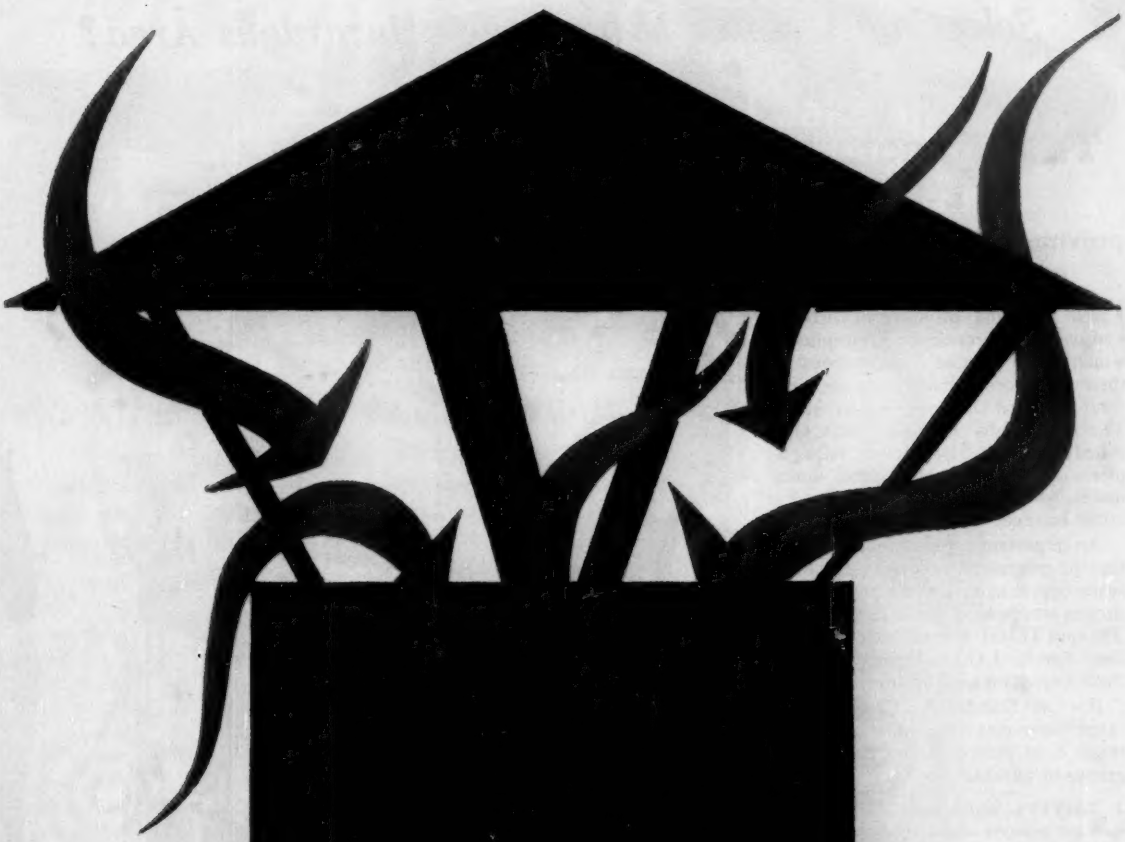
Write for your copy of Bulletin 91-123, "The Rotameter Sheds Its Limitations".

Fischer & Porter Company, 180 County Line Road, Warminster, Pennsylvania.

FP FISCHER & PORTER COMPANY

Complete Process Instrumentation

These MANUFACTURING AFFILIATES carry Fischer & Porter engineering designs to the far corners of the earth: FISCHER & PORTER (CANADA) LTD., DOWNSVIEW, ONTARIO • FISCHER & PORTER LTD., WORKINGTON, CUMBERLAND, ENGLAND • FISCHER & PORTER G.m.b.H., GROSSELLERSHAUSEN, BEI GOTTINGEN, GERMANY • FISCHER & PORTER N.V., KOMEETWEG 11, THE HAGUE, NETHERLANDS • FISCHER & PORTER Pty. LTD., 184 HANNA ST., SOUTH MELBOURNE, VICTORIA, AUSTRALIA.



Does the air in your stacks go down?

It can happen, you know. The problem is lack of make-up air to balance fume, dust, and ventilation exhaust. This causes a partial vacuum. Without a planned make-up air system, you suffer from ineffective exhaust fans, air-starved combustion processes, uncomfortable workers. To you, this means costly inefficient operation . . . and worker absenteeism. ● Westinghouse has a unique group of air application engineers, experts in balanced industrial ventilation. Why not call them in? ● Sturtevant Division, Boston 36, Massachusetts.

YOU CAN BE SURE . . . IF IT'S Westinghouse

J80705

Selecting A Motor Drive For A Hazardous Area?

Here's how

TEIGF motors

by E-M

provide safe, dependable, economical power

Faced with the problem of driving hydrogen compressors in atmospheres which might contain hydrocarbons at their Baltimore refinery, engineers of Esso Standard Oil Company turned to TEIGF (Totally Enclosed Inert Gas Filled) Motors. Horsepower requirements exceeded the practicable limits under which explosion-proof motors could be used.

An important consideration was getting the greatest possible drive economy while operating safely in a possible hydrogen atmosphere. Three E-M 350 hp, 390 rpm TEIGF Motors are on duty at Esso Standard Oil Company fulfilling these important qualifications.

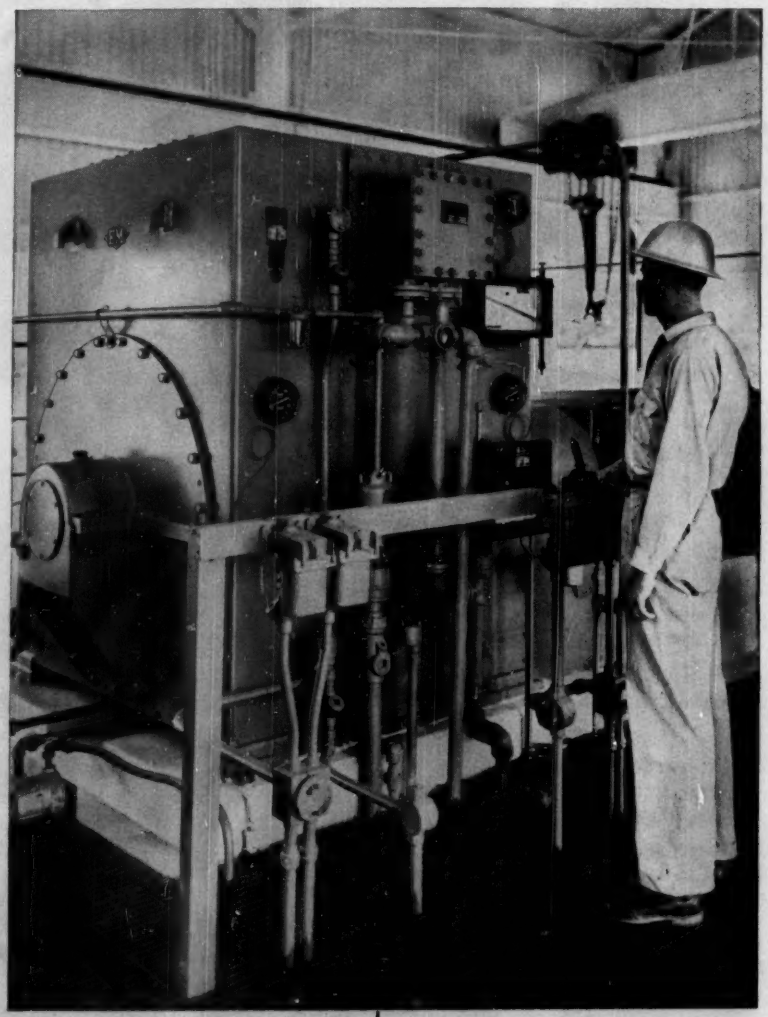
For Esso Standard Oil Company and other companies with similar problems, these E-M Motors offer three main groups of advantages:

1. SAFETY — Within the motor enclosure, inert gas pressure above atmospheric keeps explosive hydrogen *out*. A series of features help accomplish complete safety . . . inert gas pressure gauges . . . temperature gauges . . . purging valves, etc. and a full line of optional equipment. The E-M TEIGF Motor can be "customized" to meet your needs exactly.

2. RUGGED DEPENDABILITY. E-M uses specially designed "box type" frames of heavy-duty plate steel reinforced with heavy bar-stock ribs. They cannot twist or distort. Air gap is accurate and permanent, as all frame welding is completed before precision boring. Ventilating gas passages are carefully engineered to provide unimpeded gas flow for optimum cooling.

3. ECONOMICAL OPERATION. In E-M TEIGF Motors, gas loss is lower than commercially accepted standards. Specially designed shaft seals are oil-pressure gas-sealed bearing type, virtually non-wearing. Where bolts enter outside casing, E-M engineers specify blind holes . . . tapping and drilling are done *into* casing, not through. Operating and maintenance costs are at a minimum.

Consult your nearest E-M sales engineer, or write the factory for TEIGF Motor Bulletin No. 226.



TYPICAL STANDARD FEATURES INCLUDE:

1. Top-mounted gas-to-water cooler for use with suitable cooling water supply.
2. Forced-feed lubricated bearings and oil-pressure gas seals.
3. Oil pump, motor and oil filter. (Can be supplied optionally inside enclosure.)
4. Inert-gas temperature gauge.
5. Inert-gas pressure gauge.

(additional features shown in Bulletin No. 226)

TYPICAL OPTIONAL FEATURES INCLUDE:

1. Water cooler with double-tube construction for added protection against leakage.
2. Liquid level detector switch. Accumulation of moisture within motor sounds alarm or shuts down motor.
3. Bearing temperature relays, to sound alarm or shut down motor.
4. Explosion-proof motor terminal pothead or inert-gas filled terminal box.
5. Water flow indicator. Can be adapted for use with pneumatic-type regulating device.

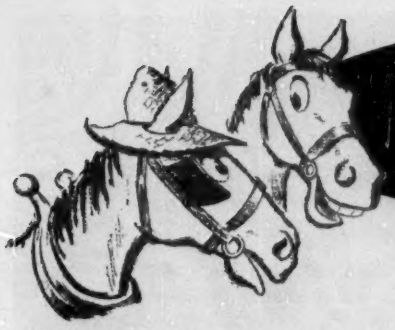
ELECTRIC MACHINERY MFG. COMPANY

MINNEAPOLIS 13, MINNESOTA

Specialists in making motors do

EXACTLY WHAT YOU WANT THEM TO

1300—TPA—2179



It's Horse Sense ... Why Chance Leaks in Seat Rings

Get Monel Seat BRONZE GATES made the way JENKINS makes them

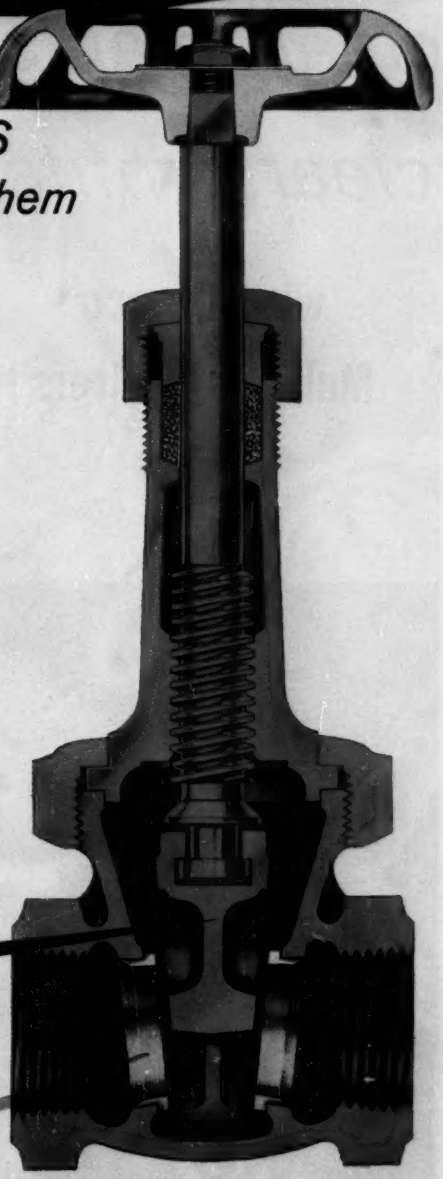
It's plain horse sense that you had better have the Monel seat rings EXPANDED (ROLLED) into the valve body if you want them to stay tight and leak-proof.

More horse sense . . . there's nothing valuable lost through having seat rings that can't be replaced by a regular maintenance man . . . **IF** the bronze or nickel alloy wedge has a lower degree of hardness than the heat-treated Monel seat rings. *(The way Jenkins makes them)* Then, the wedge takes the wear and seat rings are relatively unaffected.

Obviously, there's no faster, simpler or cheaper way to renew tightness and efficiency than to slip on a new wedge. And that, plus renewal of packing as needed, is all you need do to assure good performance from Jenkins Monel Seat Bronze Gates for as long as you'll need to care. Good service for scores of years is common.

Long, low-cost life also results from greater-than-ever-needed strength in every part of these valves. The records of millions of Jenkins Bronze Gates show you get full protection against all the stresses encountered in use.

Your local Jenkins Distributor will quickly supply your needs from a wide variety of Jenkins Bronze Gates. For information about these valves, write for folder No. 181-C. Jenkins Bros., 100 Park Ave., New York 17.



WEDGE is less hard than seat rings. Wear affects this easily replaceable part NOT seat rings

SEAT RINGS are expanded (rolled) into body. Permanent, all-around support is essential to prevent deforming, loosening, shifting, LEAKS

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

JENKINS SINCE 1864 Jenkins Bros

Sold Through Leading Distributors Everywhere

clean plants, clear profits

with Dracco Multi-Bag Filters

Freedom from dust in your plant can mean:

- **lower plant maintenance and cleaning costs**
- **less abrasive wear on machinery**
- **no raw material waste**
- **better working conditions**
- **improved manpower and machine efficiency**
- **no air pollution**
- **guaranteed product purity**

High-efficiency cloth filtration with Multi-Bag Filters can help you clear the way for profits in any or all of these areas. Wide range of standard sizes permits engineering to meet almost any dry collection requirement. Units can be installed in or out of the plant. Operation may be intermittent or continuous, depending on dust loads and degree of automation desired. Long-life filter bags are available in any type cloth, natural or synthetic.

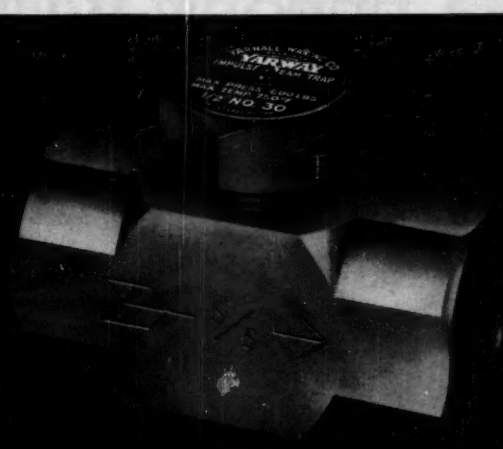
Freedom from maintenance is another benefit that helps you clear extra profits. Simplified, rugged, design with few moving parts keeps Dracco maintenance costs lowest in the industry, year after year.

For full information on Multi-Bag Filters, and other units in Dracco's complete line of dry collection equipment, write: Dracco Division of Fuller Company, Harvard Avenue and East 116th Street, Cleveland 5, Ohio.

DRACCO *airstream* conveyors dust control equipment

SPECIAL COLLECTORS
Dracco is also experienced in design and fabrication of large custom-built collectors, using glass or other synthetic cloth bags, to solve extremely severe or unusual dust problems.

Typical Multi-Bag Filter system at large eastern processing plant shows how standard units can be grouped together to provide unlimited capacities.



THIS IS THE YARWAY STEAM TRAP THAT GIVES AN EASTERN RUBBER PROCESSOR...THESE BENEFITS

MORE UNIFORM HEAT ON PLATENS
IMPROVED QUALITY OF PRODUCT
LOWER STEAM CONSUMPTION
REDUCED MAINTENANCE

THE YARWAY No. 30 WILL GIVE *YOU* ALL THESE ADVANTAGES—AND MORE! FOR EXAMPLE:

ECONOMY OF OPERATION ON LIGHT LOADS

Closer condensate control—opens wide to discharge condensate at full capacity, closes immediately on steam

LONGER SERVICE LIFE

Lever action reduces impact on valve seat—lessens wear, provides quieter operation, longer life

LOWER MAINTENANCE

Only Yarway offers an Impulse Trap with renewable seat and disc that can be quickly replaced without removing the trap from the line

Prove it to yourself . . . in your own plant.
No. 30's are stocked and sold by 270 Industrial Distributors. Ask yours to arrange a free 90-day trial . . . or write

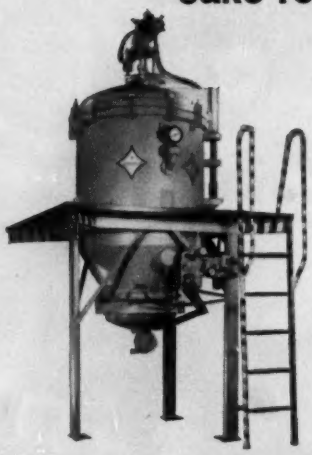
YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.

YARWAY

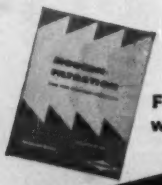
A MARK OF QUALITY IN STEAM ENGINEERING

SAVE TIME and EFFORT WITH MODERN FILTERS

Just flip the lid
. . . WHAM . . .
cake removed



These rapid cleaning devices on INDUSTRIAL filters offer tremendous advantages to the user through removal of, and subsequent disposing of waste materials or recovery of valuable solids.



For additional information write for Bulletin EP-100.

With VIBRA-SHOC or RECIPRO-SHOC, cleaning of your INDUSTRIAL filter is completed in minutes. The above mentioned trade named devices are obtainable on INDUSTRIAL'S TYPE 152 filters, as are such optional equipment as QUICK OPENING COVERS, LIQUID SHOC and AIR WASH, all designed with the efficiency you require for your particular operation. All these mechanical aids work for you to realize a definite cost savings based on reduced downtime, for either continuous or batch type operation. These self-cleaning devices also eliminate the manual dirty work in handling any dry, wet or semi-solid material.

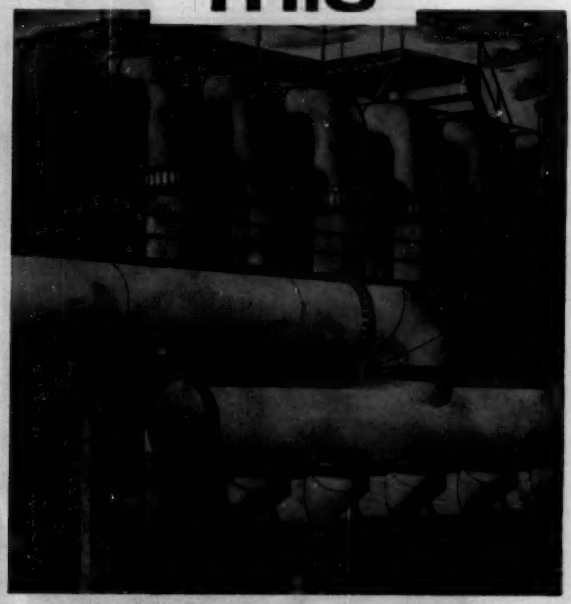
INDUSTRIAL

INDUSTRIAL FILTER & PUMP MFG. CO.
5918 West Ogden Avenue, Chicago 50, Illinois

PRESSURE FILTERS ♦ ION EXCHANGERS ♦ CORROSION TEST CABINETS ♦ PUMPS ♦ WATER & WASTE-TREATING EQUIPMENT

THE DIFFERENCE BETWEEN

THIS and THIS



is corrosion-resistant

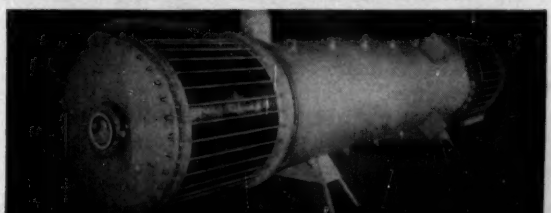
"KARBATE" IMPERVIOUS GRAPHITE HEAT EXCHANGERS!

Today, it doesn't make sense to sacrifice space, money, and minimum downtime by using heat exchangers not having the features of *unsurpassed corrosion-resistance, compactness, and low maintenance of "Karbate" impervious graphite exchangers.* Space was saved, piping simplified, and low maintenance was achieved when the "jungle" of single tube down-draft lead coolers (above left) was replaced by 6 compact "Karbate" shell and tube units (above right).

"Karbate" impervious graphite's high thermal conductivity and complete corrosion-resistance permit these heat exchangers to operate at higher velocities with associated increased heat transfer. This means that "Karbate" units with less surface area can thermally and economically replace larger metal exchangers in which high velocities produce localized accelerated corrosion. In such a case, "Karbate" exchangers with 83% less surface than carbon steel exchangers perform the same cooling job. And, at a total installed cost of approximately $10,000 less than the cost of retubing the corroded carbon steel exchangers with stainless steel tubes.

Actually, "Karbate" units offer unexcelled corrosion resistance at prices, in some instances, up to ⅓ less than many alloy and special metal units in which corrosion is measurable.

If you are considering a new heat exchanger installation, or if you have to replace or add to your present equipment, investigate the advantages of price, excellent corrosion-resistance, and trouble-free performance provided by "Karbate" impervious graphite shell and tube exchangers. For information, write National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

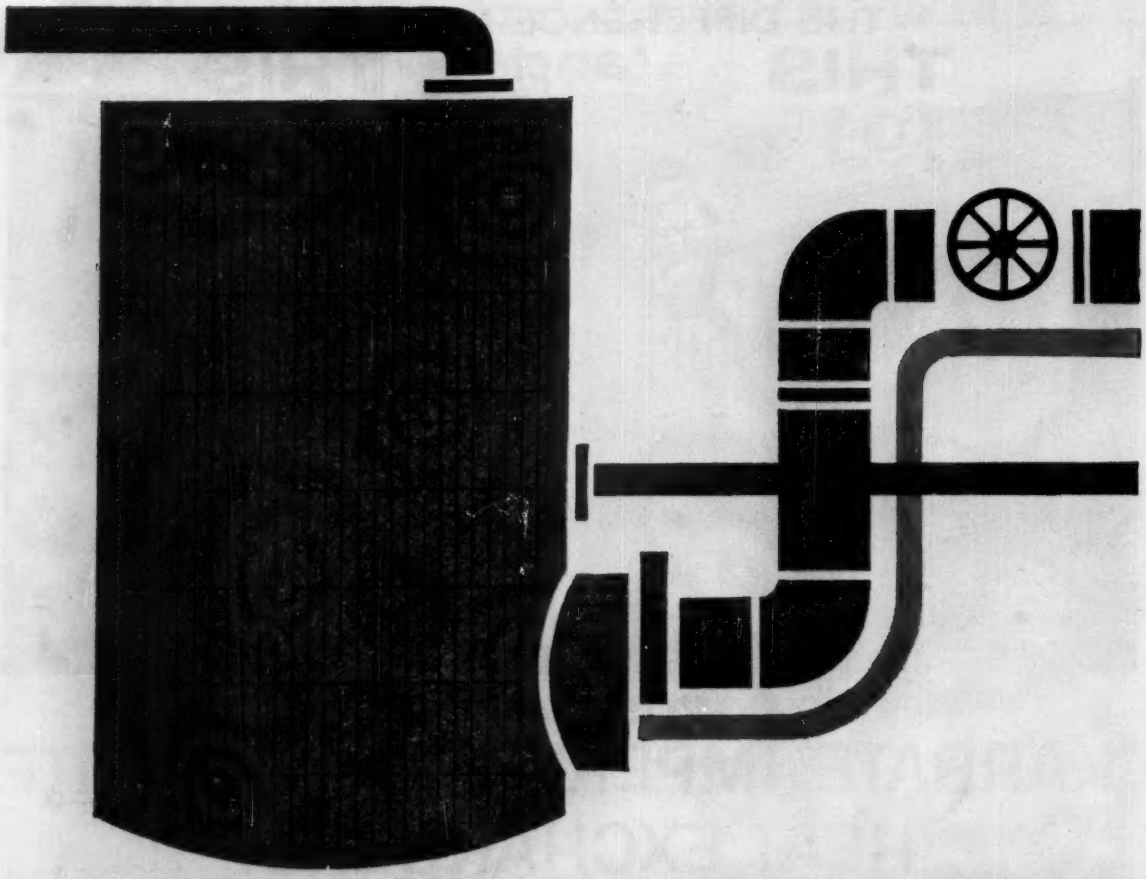


A 45" dia. "Karbate" shell and tube heat exchanger having 685 ⅞" I.D., 1¼" O.D. by 14' long tubes. It has an O.D. area of 3135 square feet.

"National", "Karbate" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY

UNION CARBIDE



FOAMGLAS® Insulation works for AMERICAN CYANAMID CO.

EVIDENCE: In 1951, American Cyanamid Co.'s Linden, N.J., plant selected FOAMGLAS insulation to solve a number of high cost insulation maintenance and replacement problems.

FOAMGLAS handled applications ranging from a brine cooler and feeder lines to steam lines operating up to 390°F—both indoors and out. The closed cell structure of FOAMGLAS insured constant insulating performance because moisture was kept out. The insulation has withstood the acid atmospheres in the plant—and with moisture and acids sealed out, external corrosion of piping and equipment has virtually been eliminated. FOAMGLAS has shown no rotting or deterioration, and maintenance has been almost nonexistent. The incombustibility of the insulation has been an important safety factor. Because of such performance, American Cyanamid has continued to use FOAMGLAS in this and other tough industrial applications even today.

See how FOAMGLAS can end insulation maintenance and replacement in *your* plant. Write for our American Cyanamid Case Study report and our Industrial Insulation Catalog. Pittsburgh Corning Corp., Dept. H-80, One Gateway Center, Pittsburgh 22, Pa. In Canada: 3333 Cavendish Blvd., Montreal, Quebec.

Pittsburgh Corning makes available a complete line of accessory materials for use with FOAMGLAS insulation. Write for Data Sheets.

PITTSBURGH PC CORNING

DEVELOPMENTS . . .

AUGUST 8, 1960

Chementator

T. PETER FORBATH

Stauffer has finally cleared obstacles from its path into the West's trona fields. Company reports construction has started on 200,000-ton/yr. soda-ash-from-trona plant at Green River, Wyo., to be on stream in 1962. A new process will be used.

Scientific Design is offering a new fumaric acid flowsheet suitable for small (2-million-lb./yr.) package plants. Process employs a new catalyst, gets high yields, "is based on moderate isomerization conditions."

Montecatini has licensed the Katschmann route to dimethylterephthalate (oxidation of p-xylene) from Chemische Werke Witten. Italian firm plans DMT plant for entry into polyester business.

Benzene oxidation lures phenol makers

"Direct oxidation of benzene" continues to be a magical phrase for phenol makers. And in recent months, they've heard it pronounced temptingly by more than one process developer even though no such process has yet proved economical on a commercial scale.

In June, Scientific Design Co., New York, declared that it had developed a process that "in effect, makes possible the direct oxidation of benzene to phenol." Last month, with the buzzing over SD's announcement hardly subsided, the Japan Atomic Research Institute, Tokyo, reported that it had piloted a direct oxidation phenol flowsheet using radiation processing. And not much earlier (*Chementator*, Nov. 16, 1959, p. 92), the Russians indicated that they were planning to build a 10,000-ton/yr. plant, harnessing radiation to the job of directly oxidizing benzene to phenol.

Patents on the Japanese process are now pending. And *CE* learns that plans are currently under investigation to commercialize it. In process, a benzene-water mixture is introduced to an autoclave with oxygen at 30 atm. A metal catalyst, identified only as a transition element, is added. Then the autoclave is heated to 200-300 C. while being irradiated by a cobalt-60 source.

Chief lure of processes such as this one is the promise of considerably simpler, thus cheaper, phenol plants than are possible with the usual processes. But clouding this hope is the fact that direct-oxidation routes provide very poor yields since phenol oxidizes much more readily than benzene. In fact, many experts feel that a true direct-oxidation process cannot be economically feasible unless a "new principle is discovered" to prevent the oxidation of phenol. Some are willing to acknowledge that radiation might prove to be that new principle.

But, though virtually nothing is known about SD's new process, it's not believed to involve radiation or any other radically new

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principle. Thus, most observers are inclined to interpret the words "in effect," which SD pointedly includes to qualify the description of its new process, as meaning that the process isn't a true direct-oxidation route but involves intermediate stages and products.

Cheap source for superphosphoric

Two more firms have entered the superphosphoric acid business. But unlike their predecessors, these two come into the field with a process that feeds on ordinary wet-process acid instead of costly furnace acid.

The Bunker Hill Co. last month began producing 70% P_2O_5 acid in a 10,000-ton/day plant at Kellogg, Idaho, using a process developed by Collier Carbon & Chemical Corp., Los Angeles. Under special licensing agreement, Collier gets all of Bunker's output for use in the manufacture of 8-24-0 (N,P,K) liquid fertilizers and other high-analysis liquid and solid phosphates.

In starting with wet-process acid instead of furnace acid, the Collier-Bunker venture acquires a significant competitive edge over the other superphosphoric acid producers, a Collier spokesman maintains. Reason: 54% P_2O_5 furnace acid sells roughly for $88/ton, while comparable wet-process acid is priced under $80/ton.

Admittedly, by starting with wet-process instead of furnace acid, Collier-Bunker gets a somewhat lower P_2O_5-content product. For example, Monsanto's new superphosphoric acid plant at Addyston, Ohio, turns out 76% P_2O_5 material as compared with Bunker's 70% P_2O_5 acid. But, Collier points out, the difference consists of trace elements such as magnesium, calcium, iron and sulfur, which are desirable soil nutrients.

Black-masterbatch output booming

Carbon black masterbatch is booming. Latest case in point: United Carbon Co.'s announcement last month of a 50-million-lb./yr. capacity increase at its 150-million-lb./yr. Baytown, Tex., plant.

United's expansion comes in the year that industry observers expect to see masterbatch output top 400,000 long tons. This will mean a new production record for the third year in a row, almost doubling 1959's 258,000 long tons and just about tripling 1958's 133,000 long tons. Between 1953 and 1958, masterbatch output held fairly steadily around 100,000 long tons/yr.

Behind this boom, as is so often the case, stands new chemical engineering technology. Masterbatching—the technique of adding carbon black to styrene-butadiene rubber in the latex stage rather than by costly, messy dry milling in Banburys—was first developed around 1944 by the government. But the process required use of dispersants that resulted in product with 5-10% less wear resistance than Banbury-milled compounds. It wasn't until Columbian Carbon pioneered the way with a dispersant-free process (*Chem. Eng.*, July 1957, p. 164) in 1957 that the rush into masterbatch production began. Finding that NDA (no dispersant added) material offered 15-20% greater wear than Banbury-mixed compounds, Phillips, Goodrich-Gulf, General Tire, Texas-U.S. Chemical, Copolymer, Firestone and Goodyear have built NDA masterbatch plants in the last two years.

United, which got into masterbatch production by buying the government's plant at Baytown in 1955, stuck with the government's dispersant-added process until its expansion last month. Now, company reports, it has developed its own, patent-applied-for NDA route, is producing a line of masterbatch with a 10% increase in wear resistance over the previous product.

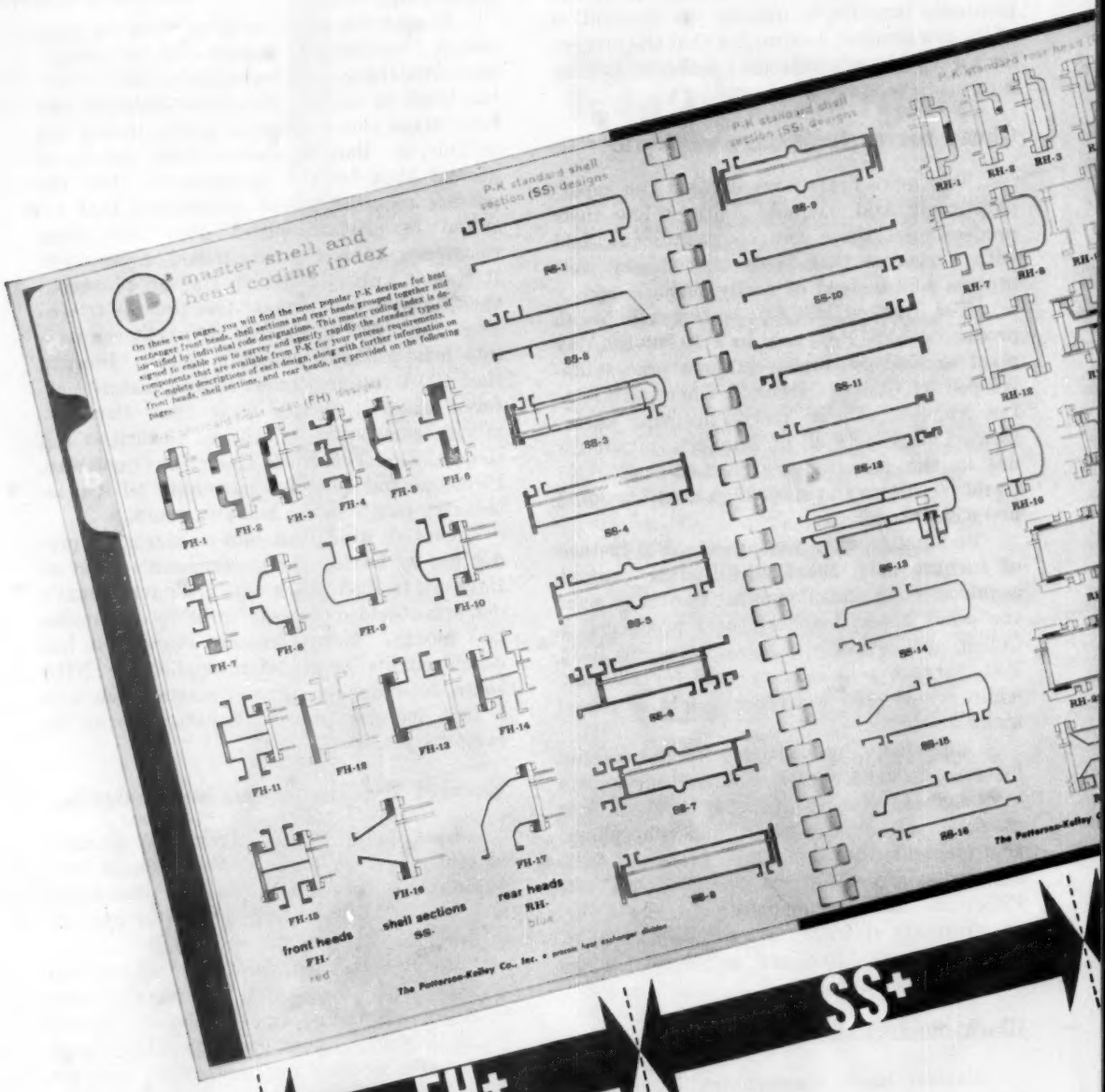
Encore: Who owns your knowledge?

Last month, the controversial question of who owns an engineer's knowledge once again was thrown into the courts. (See *Chem. Eng.*, July 28, 1958, pp. 127-130, for analysis of previous cases on this question.)

Involved this time are chemical engineer Phillip Witt, mechanical engineer Robert Calongne, and their former employer, Lummus Co., New York. At issue: whether these engineers, now in their own consulting business, may offer their services as consultants on the construction of ethylene oxide plants using oxygen oxidation of ethylene.

No, Lummus has declared, because knowledge that Witt and Calongne have on the subject was acquired while they were in Lummus' employ. And the company has obtained a restraining order in Federal District Court (Houston) that temporarily prevents them from doing so.

Case springs from an unsuccessful attempt by Witt and Calongne to "interest"


master shell and head coding index
on these two pages, you will find the most popular P-K designs for heat exchanger front heads, shell sections and rear heads grouped together and standardized by individual code designations. This master coding index is designed to enable you to survey and specify rapidly the standard types of components that are available from P-K for your process requirements. Complete descriptions of each design, along with further information on front heads, shell sections, and rear heads, are provided on the following pages.
P-K standard shell section (SS) designs
P-K standard front head (FH) designs
P-K standard rear head (RH) designs
front heads FH- red
shell sections SS-
rear heads RH- blue
The Patterson-Kelley Co., Inc. • process heat exchanger division
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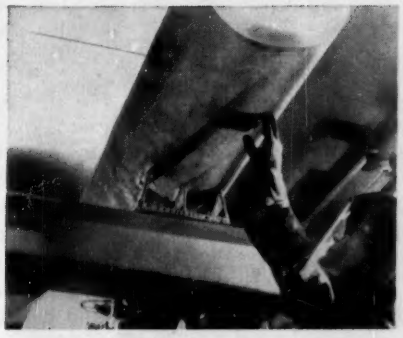
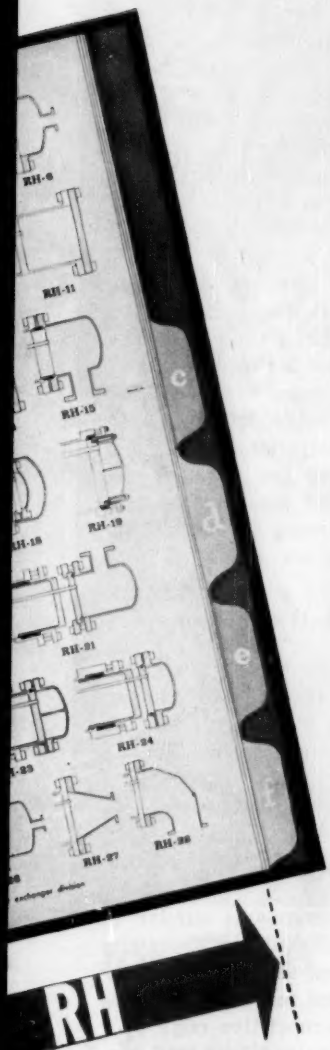
SS+

NEW SIMPLE FORMULA IN P-K HEAT EXCHANGER



AEC using P-K Heat Exchanger. This P-K Heat Exchanger runs 24 hours a day, 5 to 7 days a week, at the Uranium Processing Plant at Weldon Spring, Mo., operated for the AEC by Mallinckrodt Chemical Works. Although placed in operation in April 1958, and handling highly corrosive hydrofluoric acid at temperatures above 300°F., this two-pass shell and tube type unit has never once required maintenance.



Select the *Front Head* you want, from the *FH* group. Add the *Shell Section* you want, from the *SS* group. Add the *Rear Head* you want, from the *RH* group.

Follow these three simple steps and the formula above enables you to select the "designed" heat exchanger that meets your requirements.

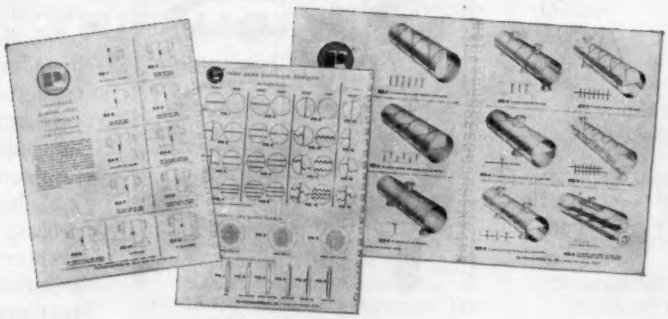
As you can see, the two pages at left from the new P-K Heat Exchanger Manual provide a master coding index. This makes it possible to rapidly survey and specify the standard interchangeable components available from P-K. Succeeding pages treat design features of each component in detail and save you time when you want to determine their suitability for your application.

Suppose, for example you want an exchanger with the following: front head bonnet, multi-pass, radial flanged connections; shell section with straight tube floating head, and pull through removable bundle construction; straight tube floating rear head, pull through removable bundle and shell cover plate, with multiple pass. Consult your P-K Manual, pages b-1 through b-18. Then specify FH-10+SS-10+RH-14.

Clear, parallel picturization of standard gasket joints, tube pass partitions, shell baffles and other components simplifies the underlying details of designs.

Other sections of the manual standardize terminology, review fundamentals of heat transfer and design, even discuss economic considerations.

Since available copies of the new P-K Heat Exchanger Manual are limited in number, they are reserved primarily for those in the process industries who can most profitably use the information. If you design or specify heat exchangers, write us on your company letterhead, outlining briefly the areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. The Patterson-Kelley Co., Inc., 112 Burson Street, East Stroudsburg, Pa.



MANUAL HELPS YOU SELECT YOUR HEAT EXCHANGER

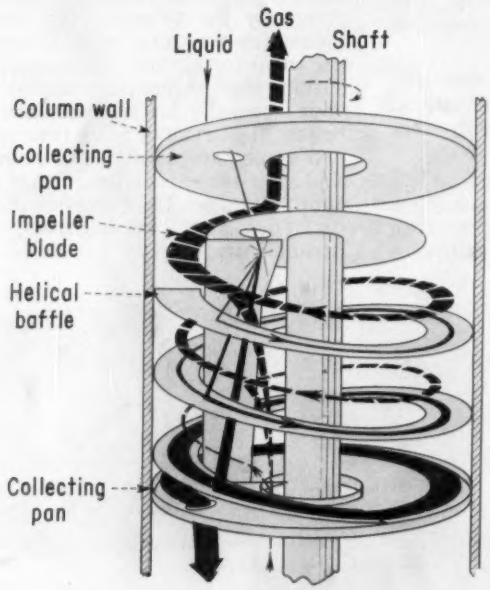
Patterson Kelley
Heat Exchanger Division

Jefferson Chemical in allegedly secret process details of Shell Development's oxygen-oxidation ethylene oxide process. Lummus points out that it—and consequently Witt and Calongne—was privy to the secret information as constructor of Shell's and Shell licensees' ethylene oxide facilities.

In its petition, Lummus claims to have suffered substantial damages, exceeding $10,000, because of the two engineers' actions. But a company spokesman tells *CE* that the chief reason Lummus is pressing suit is in order to protect Shell's know-how with which it was entrusted.

Witt and Calongne emphasize that they received no payment from Jefferson. Moreover, they claim that they properly described process details as belonging to Shell and Lummus but noted that details had been published in professional magazines.

Ultralow-pressure column unveiled



Chemical engineers are expressing lively interest in the new ultralow-pressure distillation column sketched above, which was unveiled at the recent Mexico City meeting of the American Institute of Chemical Engineers.

Designed by Donald Othmer of Brooklyn Polytechnic Institute and piloted in a 10.5-in.-dia., three-stage unit at the college, new column has rotating-tray stages that compress rising vapors as they pass from tray to tray. As a result, pressure in the column top can actually be higher than in the still.

An ordinary multiblade centrifugal compressor impeller is mounted on a rotating vertical shaft in a cylindrical column with clearance between blades and column wall. Several baffles are installed in the space between blades and wall, winding upward in a helix. Rotor is closed at top and bottom with suitable liquid and vapor openings.

Sketch above shows one impeller blade and vapor and liquid paths. Liquid is directed from stage above into path of the blade. Impact forms liquid film, which is thrown curtain-like toward wall by centrifugal force. Liquid hits wall, then runs down helical baffles. Vapor is drawn up inside the impeller and slightly compressed as it's pushed out through the blades. It contacts liquid not only on the blade face but also between baffles on its spiral journey up into the next stage.

New route may break L-D steel monopoly

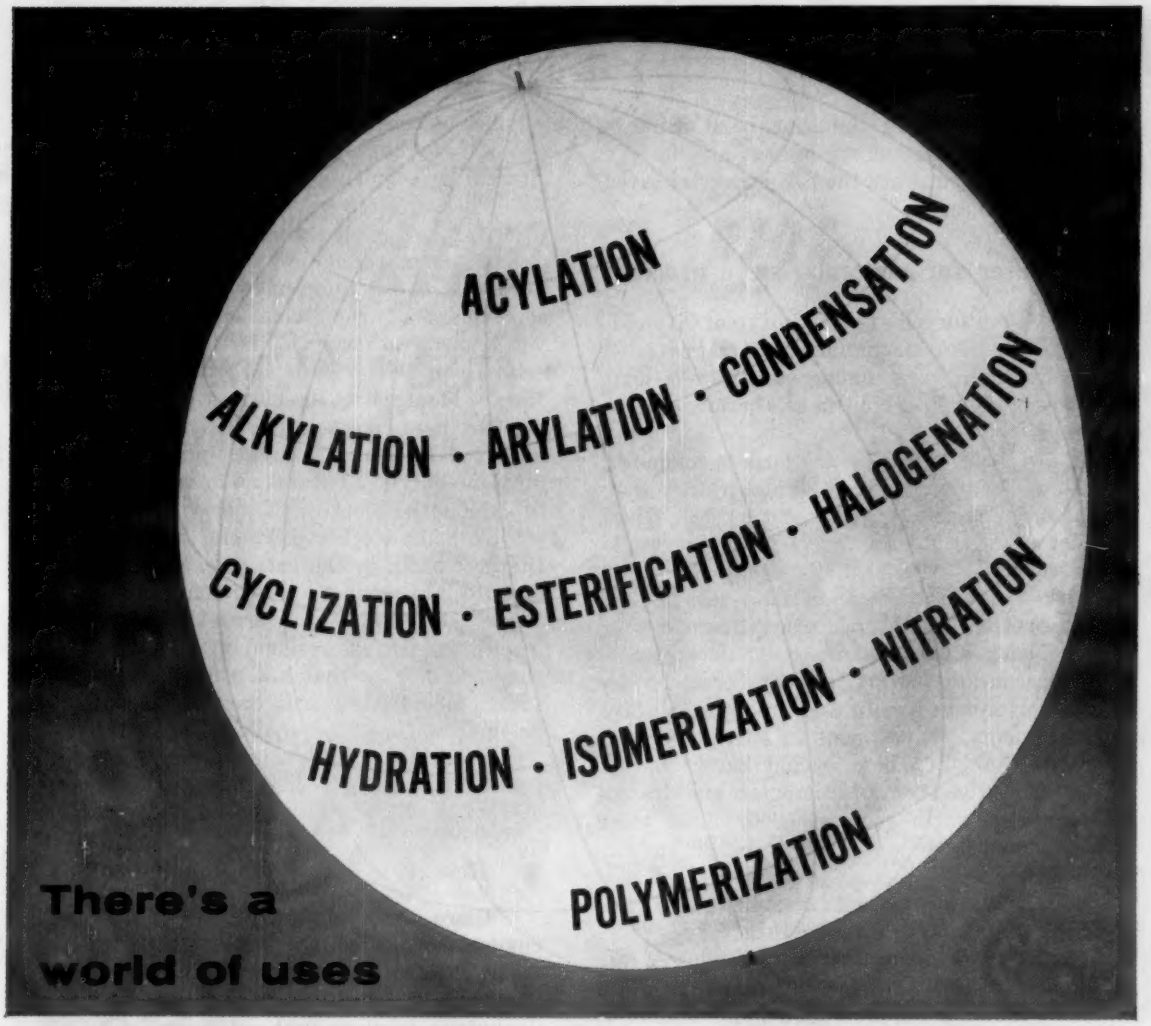
U.S. steel industry is closely watching results of shakedown runs of two 110-ton Stora-Kaldo basic-oxygen-steel converters at Societe Lorraine de Laminage Continu (Sollac) in Seremange, France. And Dravo Corp., Pittsburgh, licensor of the S-K process, expects these first "showcase" commercial units to lead to orders for S-K converters in this country.

Although the S-K process is similar in principle to the well-established Linz-Donawitz basic-oxygen-steel process, the S-K converter includes unique mechanical features which its backers feel give it a competitive edge over L-D units. And data obtained on heats running up to 130 tons at Sollac are proving out this superiority, Dravo claims.

Two chief advantages claimed for the S-K process are 2-4% higher ingot yields and greater metallurgical control. Shaped like Bessemer converters, S-K units differ from L-D converters in that they operate about 17 degrees from vertical and rotate on their longitudinal axis during a blow. Rotation gives operators an added element of control.

Tilted operation forms a roof over the molten bath and allows oxidation of most of the carbon monoxide to CO_2, giving greater thermal efficiency. Thus, converter can handle up to 45% scrap in a charge. Phosphorus and sulfur removal are also said to be excellent.

Cost of S-K converter will be about the



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Boron Trifluoride, Ether Complex, Tech	DA-34711
Boron Trifluoride, Monoethylamine Complex, Technical	DA-34661
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same as an L-D unit. Additional cost of rotating equipment is offset by savings in gas cleaning system since the S-K converter gives off less fumes.

Computer for molecular-sieve process

With a surprise twist, Universal Oil Products Co. and Daystrom, Inc., have just revealed the first hardware coming out of their joint study of computer control (*Chementator*, Apr. 6, 1959, p. 72).

Twist: a small, special-purpose computer, called Flowcon, has been picked, rather than the large, general-purpose unit used in initial pilot studies. Reason for surprise: process to be controlled is Molex, though earlier pilot work had centered on an unidentified UOP process that includes a fractionation tower.

Molex, a fixed-bed molecular sieve adsorption, separates normal paraffins from higher octane branched-chain and aromatic gasoline components. Investment in a refinery unit, roughly $1½-2 million, would barely be affected by addition of computer and instrumentation worth about $30,000. Since some instrumentation would be included anyway with the non-computer-controlled plant also being offered, the small investment in a computer might pay out handsomely.

Designed to control 24 variables in the process, Flowcon has four inputs and two outputs. With these, the solid-state computer is expected to meet a process objective of tightening product specifications at lowest operating cost.

Tomorrow's Technology

Today's embryonic developments which have special significance for chemical engineeers

"Live" molecules new polymers

Research by Germany's Farbwerke Hoechst is pointing the way to new olefin block copolymers that may find wide industrial use.

Company has discovered that, by regulating temperature, Ziegler-catalysis polymers can be made to grow remarkably slowly, "almost as if the macromolecules were alive." As a result, polymerization can be stopped easily at any point and blocks of any homopolymer or copolymer added to the chain. In this way, symmetrical molecules of regularly alternating segments can be built up.

Block copolymers of ethylene and propylene, for example, because of their regular crystal structure, exhibit greater clarity and impact strength than corresponding random copolymers of the same olefins. It's not yet known, however, if the improved properties would justify extra production costs. Italy's Montecatini is currently building a 20,000-ton/yr. plant at Brindisi to make random copolymers of ethylene-propylene and ethylene-butylene but has no immediate plans to exploit the block-copolymer variation.

To make block copolymers, Hoechst adds the first olefin to the catalyst and diluent in an autoclave against a positive nitrogen pressure. At the end of a predetermined polymerization period, residual monomer is less than the amount that has polymerized. The second olefin monomer is then introduced and polymerized onto the chains already started. By repeating this technique, chains of any desired length and composition can be constructed.

Research and development briefs

Glass as strong as steel can be made by combined chemical and thermal treatment, claim Russian researchers at the Mendeleev Institute of Chemical Technology, Moscow. Technique involves first softening industrial sheet glass by heating to 200 C., followed by immersion in a hot organosilicon bath. Process is said to increase glass bending strength by as much as 11 times.

Thermionic conversion of heat to electricity at relatively low temperatures and high efficiencies is possible in a new device developed by Radio Corp. of America, Princeton, N. J. Thermionic tube operates at 1,100 C. and 14% efficiency. Previous devices achieved "acceptable" conversion efficiencies only at temperatures above 2,000 C.

Total synthesis of chlorophyll-a has been reported by Harvard's Robert Woodward. Earlier this year, Martin Strell of Germany's Munich Technical Institute published a chlorophyll synthesis, but his product was a racemic mixture. Woodward's accomplishment should help understanding of the role chlorophyll plays in plant-life photosynthesis.

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DEVELOPMENTS . . .

PROCESSES & TECHNOLOGY

C. S. CRONAN

Industrial Water: Will It Be Scarce by 1980?

Will future industrial growth in the U. S. be limited by the available water supply? Yes, in certain areas, says the U. S. Dept. of Commerce, but the over-all supply will be ample. But another expert claims that predictions of shortages rest on doubtful projections of industrial water usage.

According to Commerce's Water and Sewerage Industry and Utilities Division, U. S. industry will use about 115 billion gal./day by 1980, an increase of 100% over the present level. Of this, about 80% will go into the metals, chemicals, pulp and paper, and petroleum and coal industries. But not all has to be fresh water, and the Commerce report indicates that only those areas which already have tight water supplies can expect future trouble.

Writing in the *Geographical Review*, Dr. Gilbert White of University of Chicago pooh-poohs reported shortages. He claims that industrial users frequently adjust their processes and facilities to the available water supply, thus plants using water for the same industrial process may report widely varying usage based on units of production.

Fiber Board From Wood Chips, Sulfite Liquor

A process for making fiber board out of troublesome pulp-industry wastes is stepping up into the pilot-plant stage of development.

U. S. Plywood Corp. is building a pilot unit at Redding, Calif., large enough to produce board for extensive market tests as a joint venture with the process' developer, Sheetwood Products Co., Seattle. If pilot-plant operations and market tests prove successful, the two firms report that they will form a new, yet unnamed, company to handle commercialization of the fiber board. Principle applications for the product are expected in siding and sheathing in residential housing construction.

Board is made primarily from waste wood chips from sawmills and plywood plants on the West Coast. Binder comes from the pulping mills' waste sulfite liquor that currently creates a major water pollution headache in the Pacific Northwest pulp-making area.

Computers Yield Results In Dollars and Sense

One way to save a dollar—or a couple of million—is with computers. This theory has become practice with Standard Oil Co. of New Jersey, which, with 36 systems now in operation or soon to be installed in 14 countries, has become a leading computer user.

How does Standard put these machines to work? By finding jobs that are either monotonously repetitive or immensely time-consuming for human workers. In addition to handling payrolls and routine office transactions, computers help the engineer solve his problems in the field.

Inventory control—frequently the Achilles heel of a good maintenance program — has been brought to Bayway refinery by computer. Over 30,000 items are checked daily; those in short supply are ordered, and the machine even checks other items of a similar type to see if larger, more economical orders can be placed. Over-all savings: a 34% reduction in dollar value of maintenance supplies.

In other operations, a computer calculates the optimum operating conditions for gasoline production in the Baton Rouge refinery. Increased profit: almost $3,000/day. And a refinery under construction at Slagen, Norway, will cost half a million dollars less because a computer estimated costs and solved problems in process planning and mechanical design.

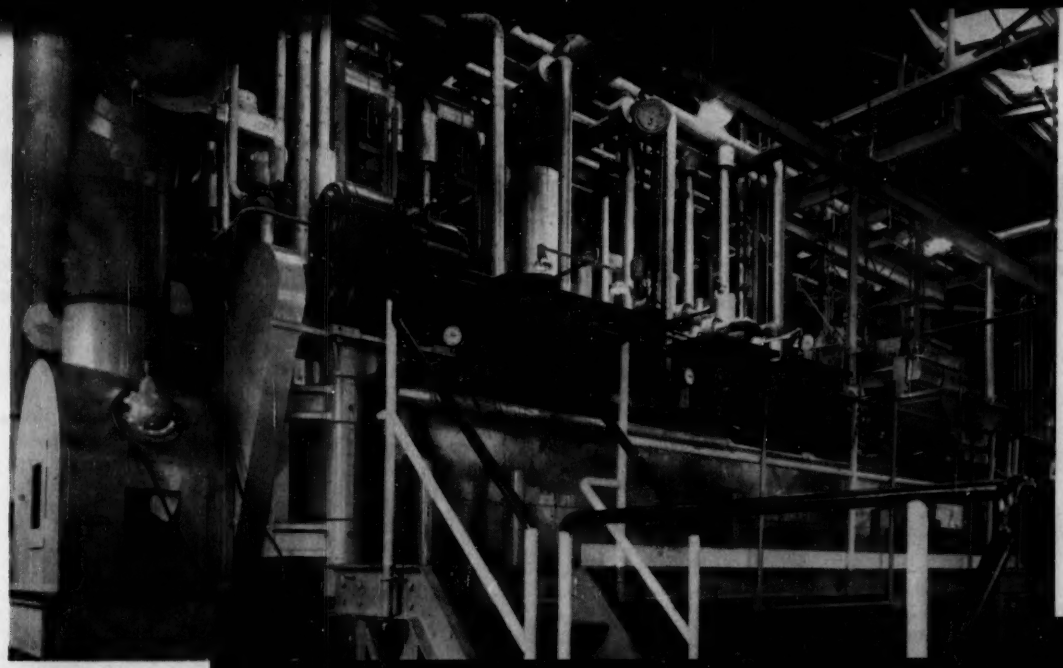
What's for the future? Increased use of computers, with systems linked together for rapid exchange of data. Standard's New York office, long a clearing house for huge amounts of information funnelling in from all over the world, will soon use computer processing to produce up-to-date, accurate, complete reports to help management make better business decisions.

Now Ethylene Oxide Can Be Shipped by Truck

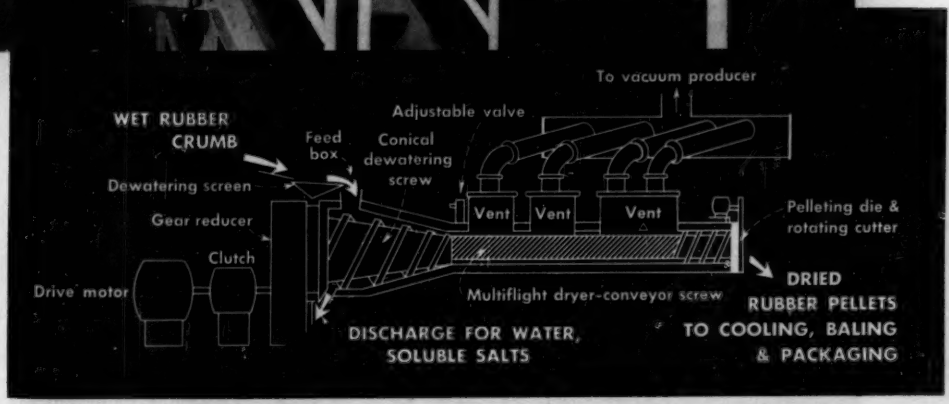
Transport of liquid ethylene oxide by truck trailer may now be possible.

Trinity Steel Co., Inc., Dallas, Tex., reports that it has manufactured the first over-the-road transport trailer for ethylene oxide to meet both strict chemical industry and Interstate Commerce Commission requirements. Until now this flammable material has been shipped exclusively by special railway tank cars. Shipment by truck, Trinity feels, should give chemical firms added flexibility, safety, economy and convenience in movement of the unstable liquid.

Trinity's new transport consists of an insulated inner shell of 115,000-psi. steel, protected by a stainless outer shell. Special overturn guards on top of the transport are designed to protect manhole covers from damage in event of a collision. All lighting and fittings are vaporproof by ICC test. And a thermocouple device fitted to the tank permits driver to keep a constant check on oxide's temperature from the truck cab.



NEW UNIT that replaced conventional three-pass dryer cuts finishing time from hours to minutes, eliminates undesirable solids.



For High-Quality Rubber, Squeeze Dry

By removing water mechanically, ash content is lowered, new doors opened for SBR products.

Commercial operation of an 8,000-lb./hr. extruder-dryer producing low-ash SBR polymers has started at Goodrich-Gulf's Institute, W. Va., synthetic rubber plant.

This new mechanical-squeezing approach, compared with conventional three-pass hot-air drying of rubber:

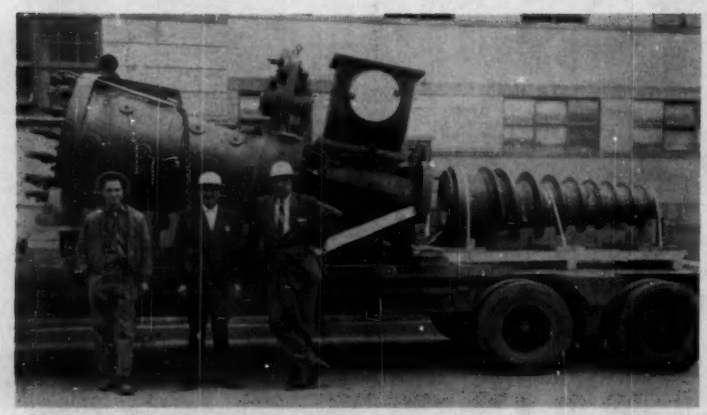
• Takes minutes rather than 2 hr. to reduce moisture from over 50% to less than ½%.

• Carries away soluble salts with the water, lowering ash content, thus opening the door for SBR rubbers to a 6-million-lb./yr. wire and cable market for electrical grade product, and to another 12-million-lb./yr. market for high-grade polymers in shoe soling and automotive extrusions. Conventional evaporative drying leaves enough inorganic impurity to bar these markets.

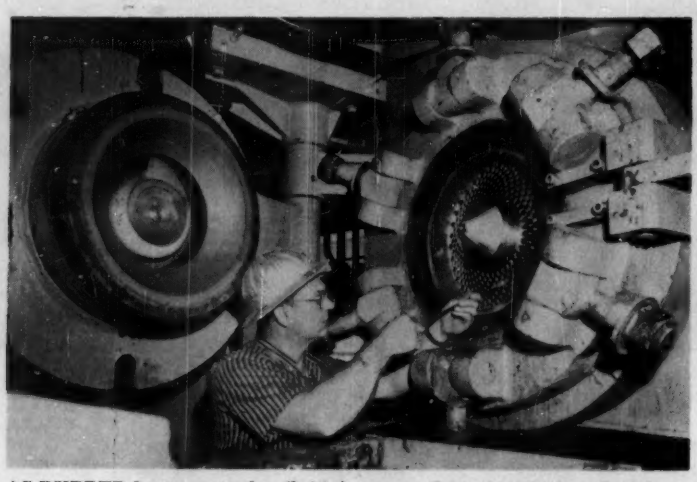
• Keeps maintenance and product contamination down, through its special corrosion-resistant alloy construction, ability to clean itself during operation. Cleaning an air dryer, a periodic necessity, takes a week, costs about $20,000/yr.

► **No Markup for Quality**—And though it is a higher quality product, rubber from the new unit will not be premium priced.

Installation of the 50-ton, 40-ft.-long unit cost $750,000: about



HEART of extruder-dryer is the massive conical screw (right) which is housed in tapered casting (left).



AS RUBBER leaves extruder (left) it passes through pelleting die (shown opened for cleaning at right).

$240,000 for the machinery and the remainder for buildings, foundation and auxiliaries.

Extruder-drying reportedly is not only more economical than conventional drying, but also than other mechanical drying methods now under development in the industry, based on modifications of the Banbury mixer (*Chem. Eng.*, June 15, 1959, p. 74). The latter, according to Goodrich-Gulf, are inferior in that their operation is batch rather than continuous; corrections cannot be made for deviations from desired moisture content without shutting down operations; they are not self-cleaning.

▶ **800-Hp. Squeeze** — The extruder-dryer at Institute is powered by an 800-hp. induction motor, coupled through a clutch to a transmission. This transmission, in turn, powers a conical screw 4 ft. long, tapering from a head diameter of 36 in. to a tip diameter of 12 in.

Above the conical screw section is a feed box. Wet crumb rubber from the leaching tanks passes over a vibratory screen, through the feed box, and into the conical screw section.

This screw, operating at a maximum of 55.5 rpm., pushes the wet rubber down the flights of the screw to an adjustable sliding cylinder valve. Under normal operating conditions, tolerances between screw threads and unit liner are held at .040 in. on a side. As the wet rubber is compressed at the valve, pressure builds up and water is squeezed out. This flows through the opening in the bottom of the conical section, carrying with it the soluble salts.

Approximately 80% of the total moisture content is squeezed from the crumb rubber in this 4-ft. conical section.

Retention time in this section is two minutes.

Linked to the end of the tapered screw and beyond the valve is a straight, 12-in. dia., 22-ft. long, multiflight screw. This is the carrier or conveyor mechanism that moves the rubber through a series of three vacuum chambers.

▶ **Valve Controls Squeeze** — At the junction of the tapered screw and the main conveyor screw is the adjustable sliding cylinder type valve. This valve adjusts tolerances between the beveled bearing surfaces of the conical screw at its discharge end and the beveled surface of the sliding valve—thus the pressure at which the rubber is worked.

Valve has an adjustment range from 0.015 to 0.125 in. The tolerance must be adjustable, so the machine can process a variety of polymers.

Rubber flows through the valve in a thin sheet equivalent in thickness to the valve settings. This creates an ideal surface area in the first vacuum vent section for removal of vapor.

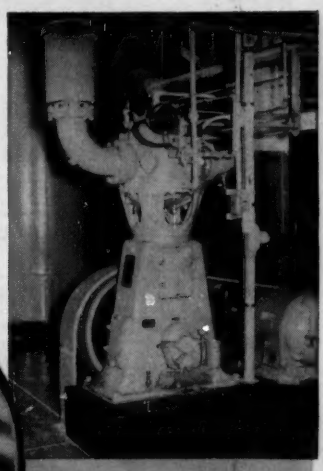
▶ **Flash Off Moisture** — When the rubber leaves the last vacuum chamber, its moisture content is at or below the standard specification of 0.5%. Vacuum in all three chambers is held at or below 27 mm. Hg absolute.

When the rubber leaves the last vacuum chamber, it is forced by the conveyor screw through a round pelleting die. This die marks the terminus of the extrusion dryer.

Temperature control throughout the process is essential to product quality and smooth machine function. The screw section is cored to permit heating and cooling. Under normal conditions, maximum operating temperature of this unit is 220 F.

Joy Design Means:

CHROME-PLATED CYLINDER WALLS FOR CORROSION RESISTANCE



Joy WGO-9 Compressors supply instrument air in southwestern power station.

Chrome-plated cylinder walls give Joy Oil-Free Compressors longer service life and lower maintenance costs. The intermittant duty typical of oil-free compressor service makes rusting of the cylinders a prime source of trouble. Because of the exclusive replaceable cylinder liner construction, Joy is able to put a chrome face on the cylinder wall which will resist corrosion and also give extra wear. This feature and the exclusive T-Block carbon-graphite compression ring construction make Joy Oil-Free Compressors economical to operate.

Joy can supply positive displacement machines with capacities up to 7392 CFM and dynamic machines in any size desired. For complete details on how to get truly low cost, oil-free air, consult your Joy representative, or write for Bulletin 926-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
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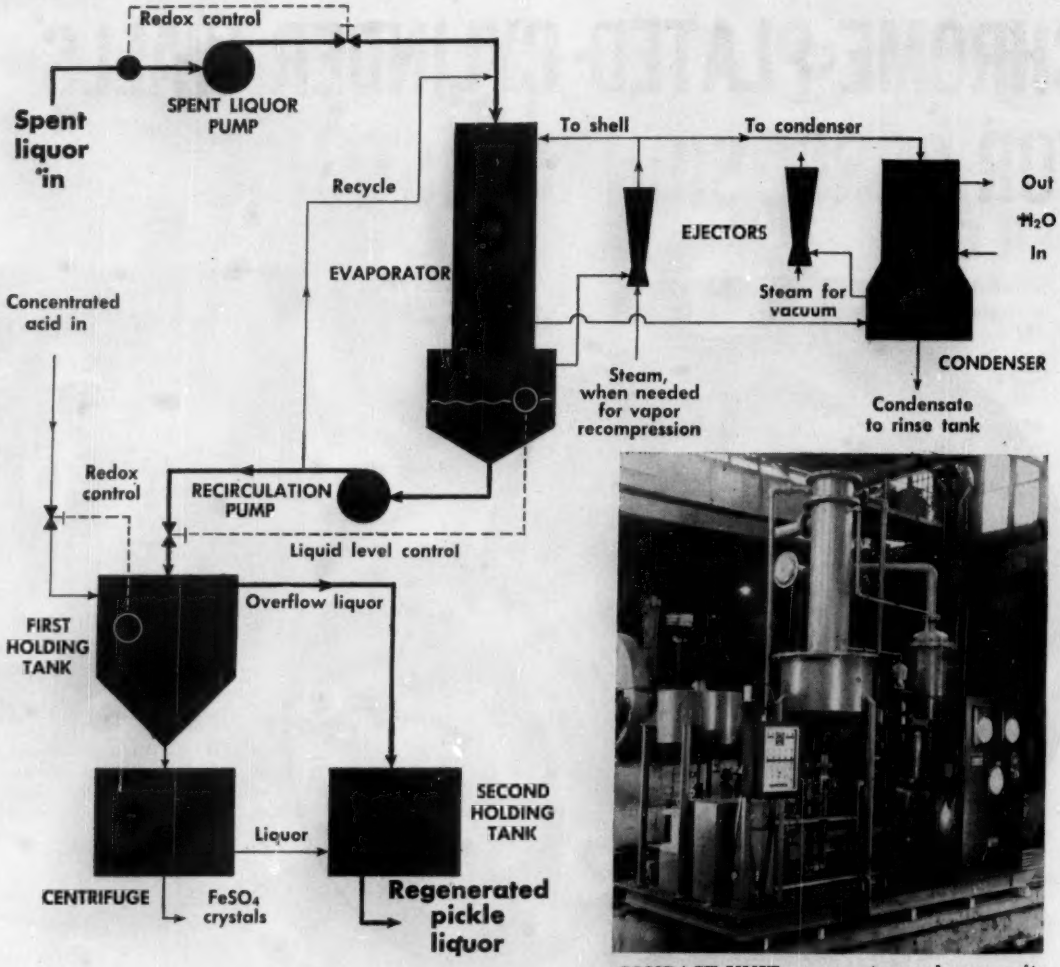


COMPACT UNIT now on stream, has capacity of 4,000 gal./day of waste pickle liquor.

'Vac' Evaporator Cuts Acid Recovery Cost

New waste pickle liquor process employs less-expensive equipment, compressed vapor for heating.

Latest entry in the derby to recover sulfuric acid from waste pickle liquor—the Belle Fons process—is off and running.

First commercial installation, a 4,000 gal./day unit erected by Salem-Brosius, Inc., Carnegie, Pa., at the Pittsburgh plant of Hanlon-Gregory Galvanizing Co., is now on stream and will soon be turned over to new owner.

And although currently operating only one shift per day, plant throughput approximates design rate of 4,000 gal./day.

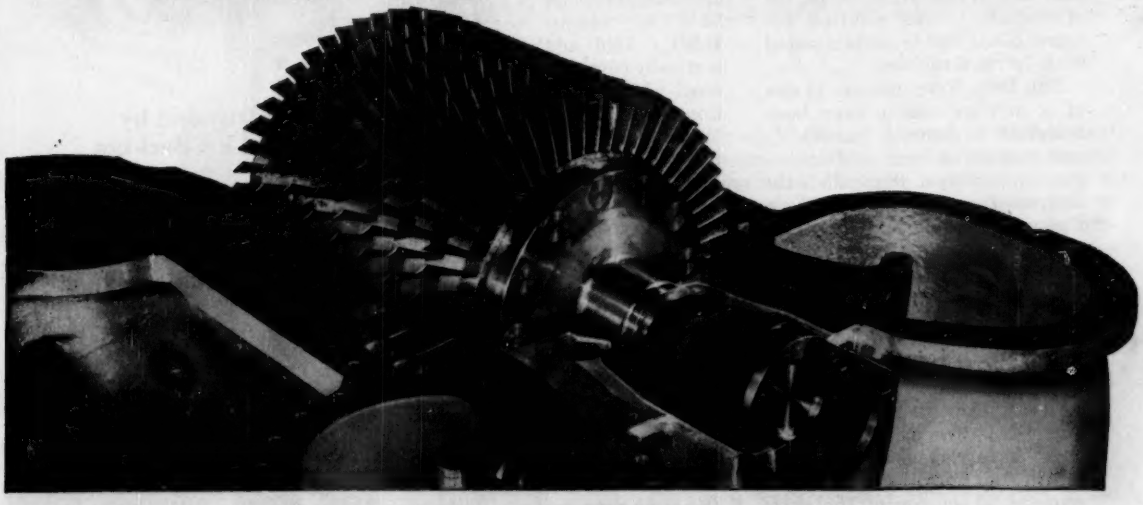
The Belle Fons process concentrates liquor by evaporating water under vacuum. This is said to offer several advantages over atmospheric evaporation. Among these are:

• Less expensive—but still corrosion-resistant — materials of construction may be used for the evaporator because of lower temperature (130 vs. 190-200 F.).

• Vapor can be compressed easily and recirculated to reduce steam requirements and minimize surface needed.

▶ **How Much Does It Cost?**—Salem-Brosius offers to build a

to 15,000 hp Axials . . .



JOY CAN SUPPLY THE COMPRESSORS YOU NEED

Joy can supply a compressor with the exact performance characteristics and physical configuration to meet your requirements, no matter how large or how small. Standard models are available, or Joy Turbodynamics engineers can design to your specifications in any size of compressor—either centrifugal or axial-flow types.

Compactness and efficiency are achieved in all Joy dynamic compressors through high stage performance. Advanced aerodynamic concepts and modern metallurgy have contributed to designs which provide the maximum of compressed air or gas for power consumed and floor space occupied.

Joy Axial-flow and Centrifugal Compressors will prove the most economical solution, whether you are compressing plant air, or process air or gas, at normal or elevated pressures and temperatures. If you have an air or gas compressing problem, check with your Joy representative or write for our bulletin "Joy Turbodynamics."

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

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plant similar to the H-G one for approximately $100,000. This will process liquor for about 1.5¢/gal., plus amortization. By comparison, liquor disposed of by dumping, costs roughly 3-3.5¢/gal. for lost acid and hauling.

At the H-G plant, only intermittent recompression of the low-pressure vapor has been necessary since feed pickle liquor, arriving at 160-170 F., gives up considerable sensible heat during the vacuum evaporation.

▶**Why Process Pickle Liquor?**—Steel users generate waste pickle liquor when they dip billets or other steel forms in sulfuric acid solutions to remove rust and scale. After a period of operation, this solution becomes dilute and is contaminated with ferrous sulfate.

The Belle Fons process is one of a number which have been designed to remove the $FeSO_4$ and recover sulfuric acid for reuse. In principle, it parallels the Koppers-Zahn process (*Chem. Eng.*, Aug. 1957, p. 168) which concentrates liquor to the point where $FeSO_4$ monohydrate crystals precipitate and can be separated. However, the K-Z process operates at atmospheric pressure, whereas Belle Fons employs a vacuum.

▶**Here's How It Works**—Spent liquor from the pickling plant is strained to remove solids picked up in the pickling bath, then pumped to the top of the evaporator (see drawing). As the liquid rises, its flow is controlled by a meter which monitors acid concentration in the stream (normally about 8.5%) and adjusts the rate accordingly.

When the liquor reaches the top of the evaporator, it flows into a recycle stream pumped from the bottom. Combined streams are then directed into the evaporator where pressure is reduced to 2-4 psia. with a steam-jet ejector. Water vapor immediately flashes off as solution passes down through evaporator tubes as a film.

In the bottom section of the evaporator, the vapor is drawn off through a metal mesh demister. It is condensed and stored in a rinse tank which serves as a source of water for diluting the final product to pickling concentration. If additional heat input is needed, the vapor can be compressed with a steam jet and returned to the shell side of the evaporator before it is condensed.

▶**Treating the Liquor**—Liquid in the bottom of the evaporator, which contains about 20-21% H_2SO_4 and some $FeSO_4$ crystals, is now at about 130 F. Part of this is drawn off as recycle and pumped to the top of the evaporator to mix with feed liquor. The recycle stream prevents evaporator tubes from running dry if there is any interruption in the feed.

Remainder of evaporator liquid goes to a holding tank where acid concentration is adjusted to 35% by adding concentrated H_2SO_4. Acid addition is automatically controlled by an instrument which monitors concentration in the tank.

When acid concentration is increased, more $FeSO_4$ precipitates until an equilibrium is reached (at about 7% $FeSO_4$ in solution). This equilibrium is independent of temperature in the 150-200 F. range when acid concentration is about 35%. (Temperature rise to 200 F. is possible when the concentrated sulfuric acid is added to the solution.)

As the crystals settle to the bottom of the holding tank, clear liquid overflows from the top into a second holding tank. At the same time, material is drawn from the bottom of the first tank into an automatic, batch, basket-type centrifuge.

▶**The Products** — Regenerated acid, which consists of overflow from first holding tank and liquid from the centrifuge, is collected in the second holding tank. This product contains 35% H_2SO_4 and 7% $FeSO_4$ as well as most of the inhibitor commonly used in the pickling operation. It is diluted to pickling concentration with rinse water recovered from the vapor condenser.

For a plant this size, the $FeSO_4$ crystals, which contain about 3% moisture, go to the dump. In a larger plant, which would process at least 30,000 gal./day pickle liquor, Salem-Brosius proposes to add roasting and sulfuric acid contacting plants to recover ferric oxide and sulfuric acid from the sulfate crystals.

▶**Construction Materials** — Original design called for much of the piping to be polyvinyl chloride, but after a short period of operation it was found that the pipe, especially in longer runs, couldn't maintain mechanical strength. Most of the PVC pipe was then replaced with a high-alloy steel, which had also been used for the evaporator, holding tanks and automatic centrifuge.

Salem-Brosius will build units with ejector recompression up to a capacity of 18,000 gal./day. Larger units would use turbine compressors for greater steam economy.

A-Waste Disposal by Foaming Gets Backing

The foam-separation process developed by Radiation Applications, Inc., Long Island City, N. Y., has won major backing in its drive toward its first commercial application. Atomic Energy Commission's Oak Ridge National Laboratory has entered into a $200,000 development program with RAI in an effort to put the patented Foamet process to work disposing of atomic fuel wastes.

According to an RAI spokesman, foam separation makes possible the concentration of radioactive constituents, with a subsequent reduction in bulk of atomic wastes, at considerably less cost than currently used processes such as ion exchange. Chief reason: Foamet system permits continuous processing, thus is mechanically simpler and requires less capital investment than other techniques.

Process involves bubbling a gas (e.g., air, nitrogen) through a solution of metal ions (e.g., nuclear wastes) to which a surface-active complexing agent (e.g., chelate) has been added. A foam, containing metal ions, is produced that can continuously be collected from the surface layer of the solution.

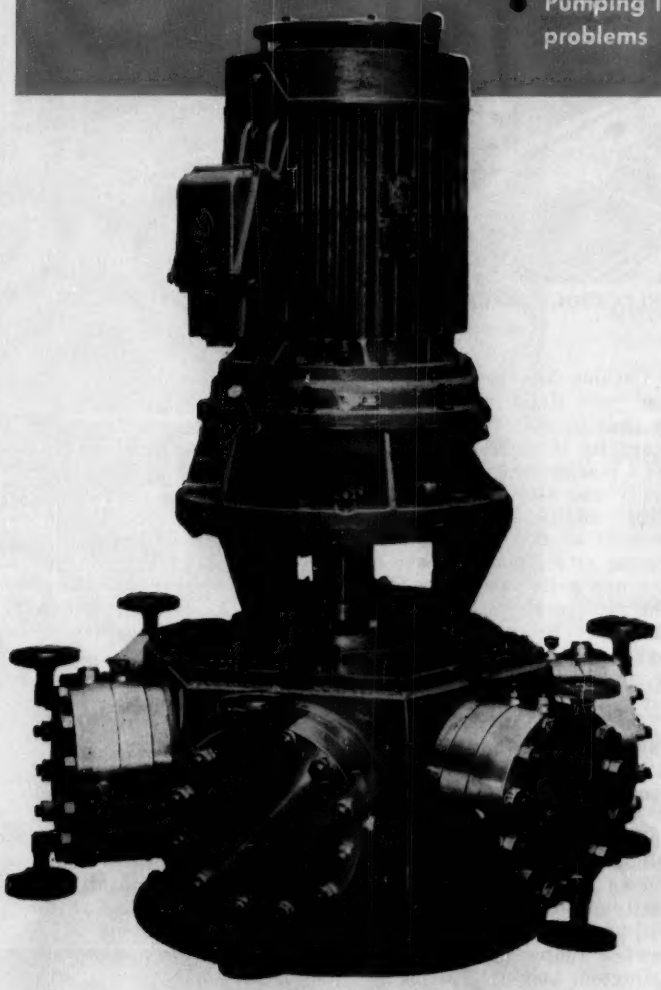
RAI has used the process for removing strontium-90 and cesium-137 from wastes produced

CORBLIN DIAPHRAGM-TYPE PUMPS

handle liquids too difficult for ordinary piston-type pumps!

CORBLIN PUMPS are designed especially for:

- Pumping liquids where NO TRACE of contamination or leakage can be tolerated
- Pumping liquids that present severe corrosion problems



Corblin pumps utilize, as their pumping members, metal diaphragms, hydraulically pulsed to provide suction and discharge action. This makes possible the pumping of hard-to-handle liquids without the slightest trace of contamination or leakage. The pumps will handle corrosive liquids without damage to the pump. This is possible because all parts of the pumps that come into contact with pumped fluids may be made of corrosion-resistant materials. Units are available in all types of stainless steel, Hasteloy alloys, copper alloys, titanium, etc.

Models are available with constant or infinitely variable outputs; capacities to 2,000 gal./hr., and pressures to 15,000 p. s. i. The unit shown at left is a six-stage pump that discharges fluid at a rate of 2,000 gal./hr., at a pressure of 2,000 p. s. i. This particular pump, built to handle radioactive heavy water, uses distilled water to pulse the diaphragms.

COMPRESSORS ALSO AVAILABLE

Operating on the same principle as the diaphragm-type pumps, Corblin compressors offer contamination-free and leak-free compression of all gases including carbon monoxide, carbon dioxide, chlorine, fluorine, ethylene, argon, helium, oxygen, air, etc. Models are available for pressures to 30,000 p. s. i.; and capacities under certain operating conditions, to several hundred s. c. f. m.

FREE BULLETIN

Aminco will forward on request a six-page bulletin that illustrates and describes many types of Corblin pumps and compressors. Send for free Bulletin 4071—C

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in the chemical reprocessing of reactor fuel elements. AEC visualizes that it could be used in compact waste-disposal systems for nuclear-powered ships.

Russia Stresses Plastics But Still Trails West

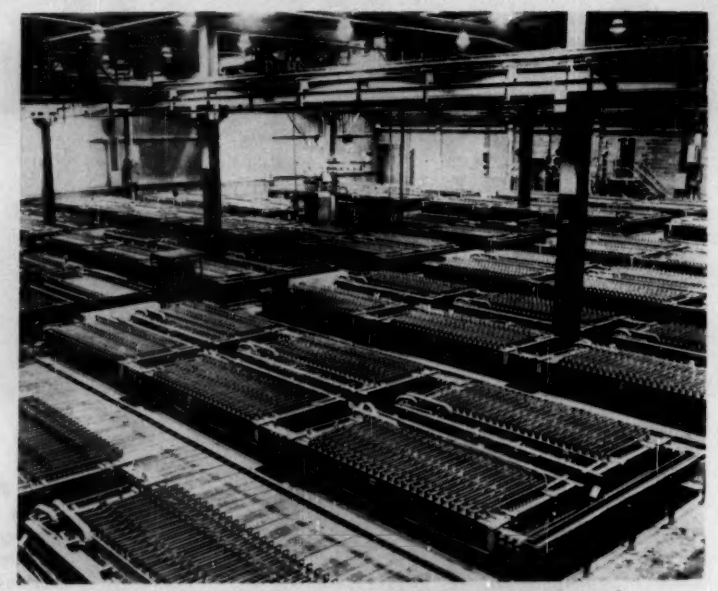
Although the Russians continue to trail the Western world by a wide margin in plastics technology, they have begun laying the groundwork for a very promising future.

This is the general consensus of the some 20 American scientists and engineers who attended the International Symposium on Macromolecular Chemistry held in Moscow last month. Meeting gathered over 1,200 polymer experts from 25 countries to listen to more than 160 technical papers and to tour various Soviet plastics research and production facilities.

According to these observers, research and development work in plastics and polymer technology has become one of the top-priority fields in the Soviet Union during the past two to three years. Long concentrating most of their "materials development" effort on steel and other metals, the Russians now are attempting to "leapfrog" the West in plastics. Moreover, they seem anxious to avoid freezing industrial development of plastics in any particular area since they recognize how quickly even the newest polymers become outmoded.

At the moment, most commercial work in the U.S.S.R. admittedly borrows heavily from Western, and especially American, plastics technology. But, observers stress, the Russians have launched major research projects in a number of relatively new and unexplored areas. Among those that most impressed Westerners at the Moscow meeting were reports on Soviet investigations of radiation polymerization, inorganic polymers and polymers with semiconductor properties (*Chementator*, Jan. 25, p. 50). One major problem that the Soviets face, however, is getting their promising research work into production.

INDUSTRY NEWS



NEW ELECTROLYTIC CELLS add to UCM manganese capacity.

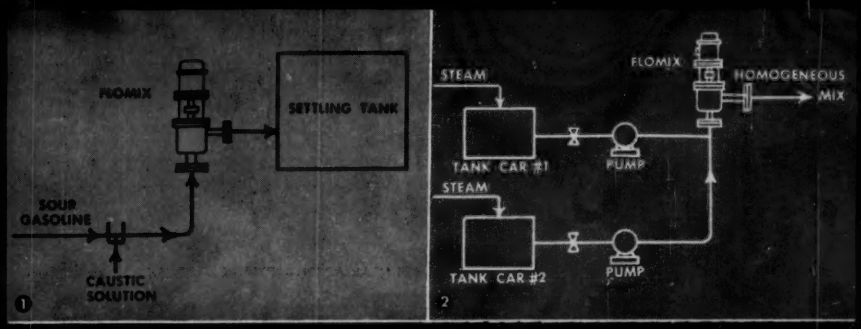
Union Carbide Metals Co., division of Union Carbide Corp., has increased by 20% its capacity to produce electrolytic manganese. The new capacity was attained by installing additional electrolytic cells at the company's Marietta, Ohio, plant; some of the new cells can be seen in the picture above. UCM's electrolytic process yields manganese that is 99.9% pure, in the form of plates about ½ in. thick.

Tidewater Oil Co. announces that it is joining with **Collier Carbon & Chemical Corp.**, of Los Angeles, in building a naphthalene plant. The multimillion-dollar venture will have an initial production capacity of 50 million lb./yr.; it will be built at Tidewater's Delaware refinery, south of Wilmington, and will be operated by Tidewater. Plant will use a patented process, developed by Union Oil Co. of California, which converts alkyl naphthalenes into high-purity naphthalene. Construction is expected to start early next year and completion is planned for the end of the year.

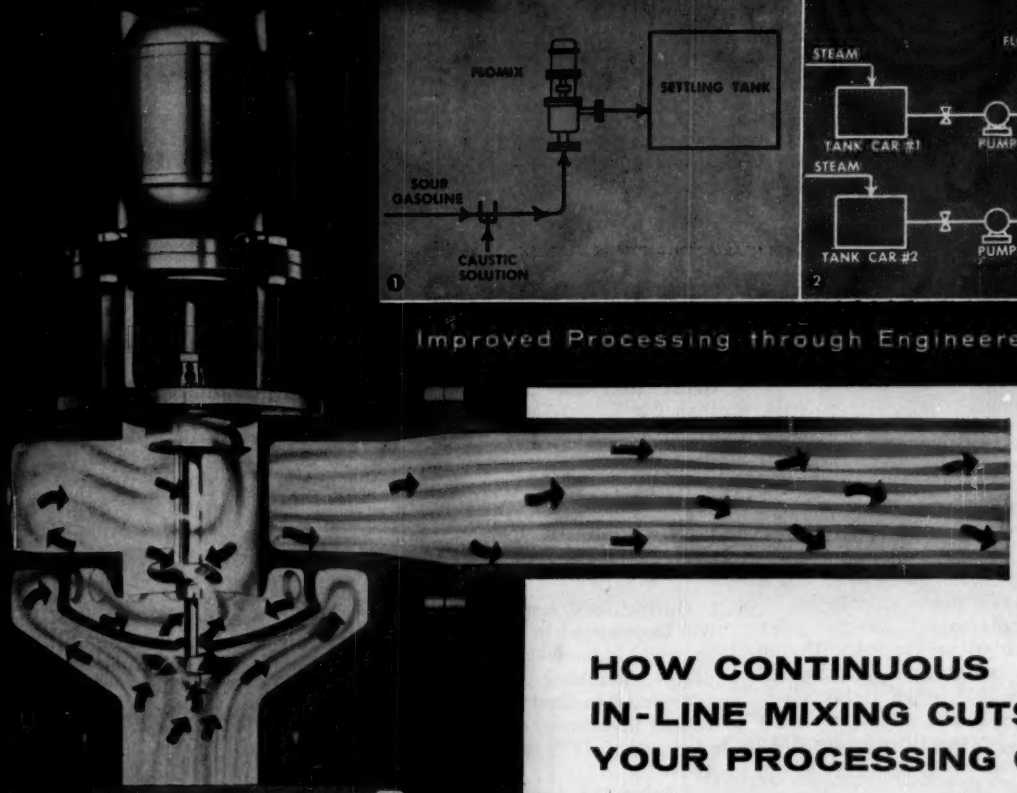
Chemetron Corp.'s Cardox Div. has placed a carbon dioxide plant on stream at Gibbstown, N. J. Facility has a capacity of 150 tons/day of liquid and solid product, which reportedly makes it the largest carbon dioxide plant in the Northeast.

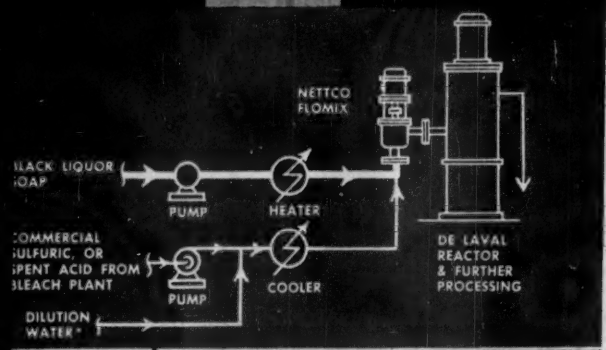
Texas Eastern Transmission Corp. plans to add 50 million cu. ft./day to the delivery capacity of its natural gas pipeline system, which will result in a new daily capacity of 2.24 billion cu. ft. Cost of the program will be about $17.5 million and construction will begin as soon as the company receives authorization from the Federal Power Commission. New facilities required include the following: about

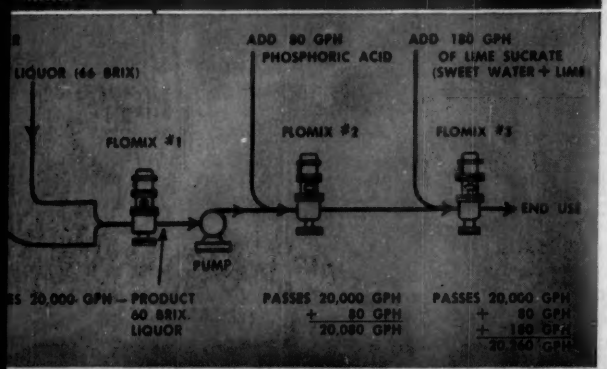
Industry News continues on page 160



Improved Processing through Engineered Agitation



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ADD 80 GPH PHOSPHORIC ACID
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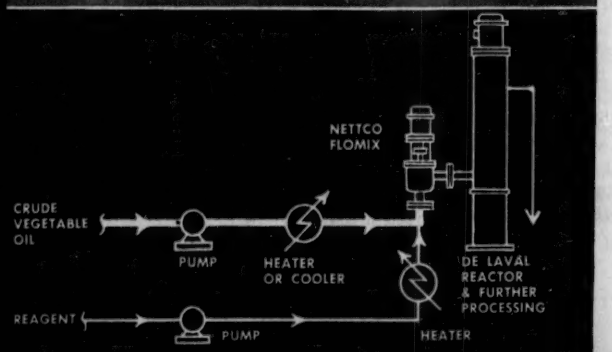
PUMP
PRODUCT 60 BRIX LIQUOR
PASSES 20,000 GPH + 80 GPH 20,080 GPH
PASSES 20,000 GPH + 80 GPH + 180 GPH



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DEVELOPMENTS . . .

CHEMICAL ECONOMICS

EDITED BY FRANCES ARNE

Costs Up, Prices Static, Chemical Profit Shrinks

Describing profit margin in the chemical industry as so thin right now that it may inhibit industry growth, Dow vice president Carl A. Gerstacker—speaking at the American Institute of Chemical Engineers' recent Mexico City meeting—fixed on static prices as a prime culprit.

He pointed out that the index of chemical prices in the United States is sitting right where it was in 1951 when it hit 110.0. By comparison, the price index for all commodities other than chemicals now stands at a new high of 128.7.

Closing in from the other direction to narrow profit margins, he sees overproduction, overcapacity, increasing cost of manpower, materials, transportation and taxes.

Rise in transportation costs, for one, was made evident by Manufacturing Chemists Assn. president John E. Hull before the New York Traffic Club recently. He cited industry estimates that put transportation costs at between 8 and 25% of total chemical sales income. If only the low percentage is used, this means that the chemical industry spent more than $2 billion for transportation in 1959.

About 28% of all tank cars in commercial freight service on U. S. railroads were in chemical service as of January 1959. More than 43% of railroad revenues from tank car movements was earned in transporting chemicals. Of the total gross revenues of U. S. railroads, 9% is derived from transporting chemical products.

According to the Interstate Commerce Commission, 20.5% of the tank truck revenues of interstate "for hire" carriers is earned in transporting chemicals. Prior to World War II, virtually no chemicals were hauled in tank trucks. Since 1947 the tonnage of principal chemicals carried on the inland waterways (exclusive of the Great Lakes) has increased more than 260%.

East Germany Raises Chemical Investments

During 1960, some $55 million will be invested in East German chemical industries, according to State Planning Commission spokesmen in East Berlin. This rate of investment constitutes an increase of 15% compared with 1959.

During the first four months of this year East German chemical production rose 9.3% compared to the corresponding period of last year. Greatest growth rates were observed in the pharmaceutical, rubber, tire and asbestos industries.

Production surpluses were achieved in nitrogen and phosphorus fertilizers. Unfulfilled production goals were reported for sulfuric anhydride, polyvinyl chloride and cellulose.

Aluminum Takes More Of Automotive Market

Stated goal of the aluminum industry—to raise consumption of aluminum in automobiles to the 250-lb./unit level by 1970, up from a 56-lb./unit level in 1960 models—is a step closer.

General Motors, which has pioneered with air-cooled aluminum engines in the Corvair, plans aluminum liquid-cooled plants in two new compacts, Oldsmobile F-85 and Buick Special, and in the Corvette.

Credit apparently goes to antifreeze producers who have recently introduced full-fill, all-year cooling system fluid that requires no addition of water. Galvanic action between aluminum and the iron cylinder walls in liquid-cooled engines, which attacked the lighter metal, has been a major roadblock to use of liquid-cooled aluminum engines. The new year-round compounds are designed to eliminate such corrosion.

New proof is available that aluminum is also going great guns in the can industry: U. S. Steel's recent announcement of a reduction on lighter-weight tin plate prices of about 4% below the standard weight tinplate, with the statement that the move was to make this kind of tin plate more competitive with other materials. Consumption of aluminum by the can industry will soar from about 15 million lb. in 1959 well above 50 million lb. in 1960, according to industry estimates. The increase reflects expanded use of aluminum instead of steel in cans for oil, beer, fruit juice concentrates and other items.

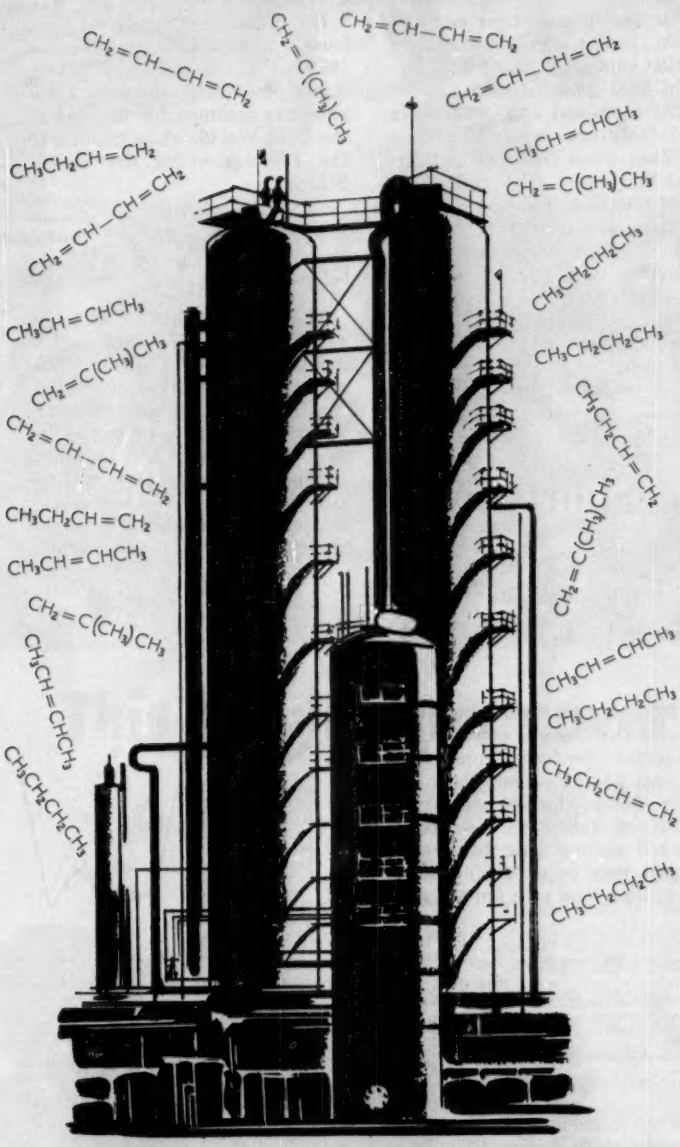
Rate of Growth Quickens For Fiber Glass Markets

According to a recently-published financial study of the scope and potential of fiber glass, total manufacturers' sales for the period 1950-1959 inclusive show an annual increment of $20.8 million, equivalent to an annual growth of 15.4%, compounded.*

The rate of growth accelerated substantially in 1959, with actual increment of $55 million, or 23.4%. Preliminary estimates for the current year indicate that the market will continue expanding along a line well above its long term trend, probably reflecting the emergence of the boat making industry as a large volume consumer.

*"The Fiber Glass Industry," by T. Koslowski, *The Glass Industry*, June 1960, p. 324.

what QO® FURFURAL offers in extraction of butadiene



QO Furfural has the unique ability to alter relative volatilities of butadiene and other C_4 hydrocarbons. This permits easy fractionation of compounds differing in degree of unsaturation. In addition, QO furfural offers:

HIGH RECOVERY: Good selectivity of the solvent assures high butadiene recovery; excellent stability of the furfural assures almost quantitative recovery of the solvent itself.

FLEXIBILITY: Furfural is effective in separating mixed butylenes as well as butadiene, thus a furfural unit can be used to prepare either alkylate stock or butadiene. The process employs petroleum-type equipment, which can be adjusted to a variety of operating conditions.

LOW SOLVENT COST: QO Furfural is produced in large quantities from agricultural residues—not from the valuable food or fiber portions of the plant. This helps keep prices low and stable.

Think of furfural whenever you want to separate a mixture of hydrocarbons. C_4 separation is but one example. Write for information on extractive distillation and Bulletin 203-A containing Physical Data.

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There are no complete statistics on the actual physical consumption of fiber glass by the boat industry but it is estimated at over 70 million lb., about double that of 1958.

Output of textile glass fibers—for use in draperies and other fabrics for insulation, protection and many industrial uses — reached 147 million lb. last year, 42% more than in 1958 and equal to about 7.5% of total U. S. production of man-made fibers.

In defense applications, fiber glass goes into missile nose cones, radar housings for aircraft, sound conditioning for jet planes, etc. Indicating the size of this market: The Boeing 707 contains over 5,000 lb. of fiber glass.

For use in passenger car and truck bodies, the automotive market consumed about 6 million lb. of fiber glass in 1959.

The combined sales of the six manufacturers who constitute the fiber glass industry put the total market at $290 million in 1959. Owens-Corning, pioneer in the field, accounted for 72.9% of that total; next came Johns-Manville with 12.1%. Other manufacturers, Gustin-Bacon, Pittsburgh Plate Glass, Ferro Corp. and Modiglass, followed in that order.

Sulfur Glut May Be Short Lived

Planned capacity looks like too much too soon. But a rein on new increases, could restore balance by 1970.

Around 1965 the Free World's sulfur demand may be some 21 million long tons annually. With no increase in Frasch and non-elemental capacities, the total sulfur productive capacity in 1965 may be some 22 million long tons. In other words, if the present plans for new capacity are maintained, there will still be an oversupply in 1965.

However, looking ahead to 1970, sulfur demand comes to about 26 million long tons. And, again, assuming no increase in Frasch and non-elemental capacities, the capacity is estimated at 23 million long tons. This means that not only may all the planned increases be needed but also three million long tons more from other sources.

These estimates were recently made by Texas Gulf Sulphur's Gino P. Giusti before the American Institute of Chemical Engineers in Mexico City. To emphasize the supply-demand position he uses "the unrealistic assumption that Frasch sulfur capacity and the non-elemental category will hold constant."

Most of the sulfur production in the United States and Mexico is from Frasch mines, whereas France and Canada extract their elemental sulfur from sour natural gas. Present plans call for a 1965 productive capacity of recovered sulfur in Canada of some 3 million long tons while France may be producing about 1.4 million long tons annually.

Sulfur Capacity
(Millions of long tons)

Source	1960	1965	1970
Canadian recovered	0.6	3.0	3.5
French recovered	1.0	1.4	1.4
Other elemental	1.6	2.0	2.5
Frasch (?)	8.0	8.0	8.0
All non-elemental (?)	8.0	8.0	8.0
Total	19.2	22.4	23.4

New capacity also will be brought in by the many present and potential producers of recovered sulfur in the rest of the world. Today, more than 40 countries produce some form of sulfur. About 30 produce elemental sulfur, led in 1959 by the U.S., Mexico, France and Canada, in that order.

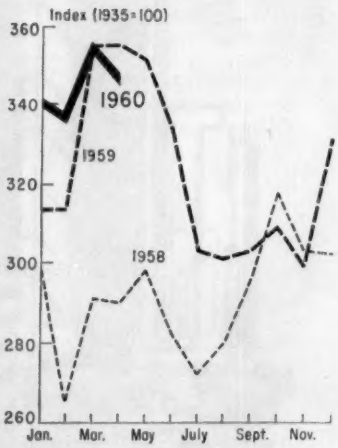
Total sulfur consumption in the Free World has grown on the average of 3.8%/yr., based on the 51-yr. period from 1908 through 1958. During this same period, the growth rate for the United States total sulfur consumption was calculated as 4%/yr.

On these growth rates Giusti based his estimates for 1965 and 1970 sulfur consumptions. As an upper possibility, however, a 6% rate was assumed for the rest of the Free World, while holding to the 4% figure for the United States.

Sulfur Consumption
(Millions of long tons)

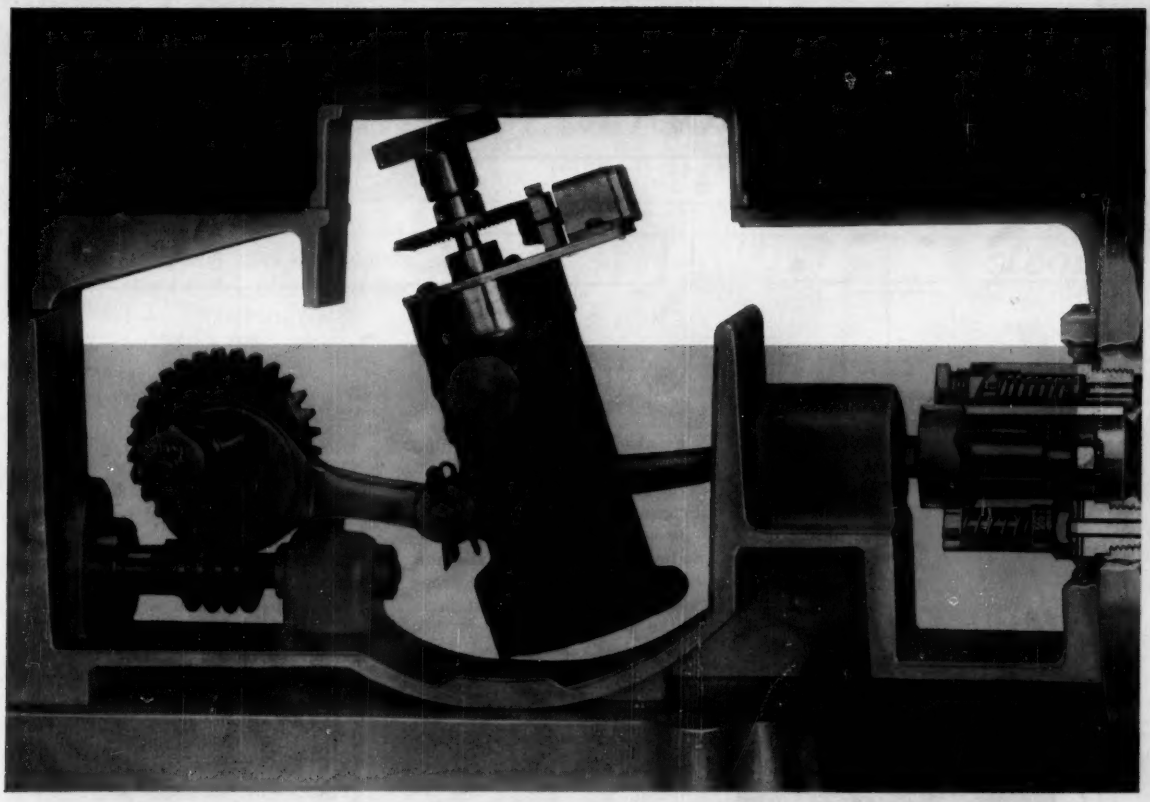
	1959	1965	1970
U. S.	5.8	7.5	9
Free Worlds	16	20–22	24–28

If only the more recent years (1946 through 1958) are used to determine the growth rate of the rest of the Free World, excluding the United States, one would learn that a rate in excess of 7% is obtained. Using this high rate in the future did not seem realistic to Giusti since it was caused by good business conditions and recovery from war periods.

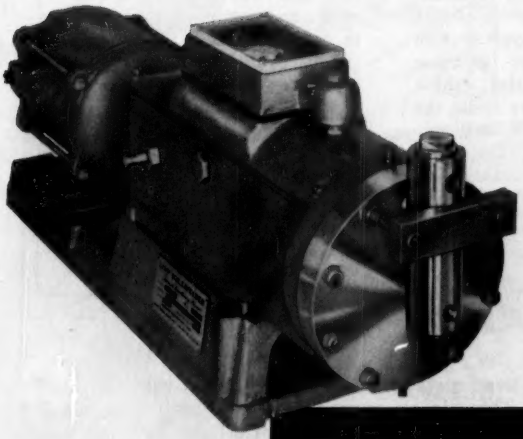


Consumption by Industries

	Mar. (Final)	Apr. (Est.)
Coal products	10.4	9.5
Explosives	10.9	12.0
Fertilizer	85.4	81.0
Glass	29.7	27.7
Iron & steel	21.2	17.9
Leather	4.3	4.2
Paint & varnish	35.9	42.9
Petroleum refining	31.8	31.0
Plastics	36.9	34.8
Pulp & paper	43.8	42.0
Rayon	26.6	24.1
Rubber	8.0	7.4
Textiles	10.8	9.9
Total	**355.7**	**344.4**



This is why you never heard of a PULSAFEEDER wearing out!



Every moving part of every Lapp Pulsafeeder Metering Pump is completely submerged in oil. This total lubrication reduces friction to practically the theoretical minimum. And there's no possibility of corrosion from exposure to atmosphere.

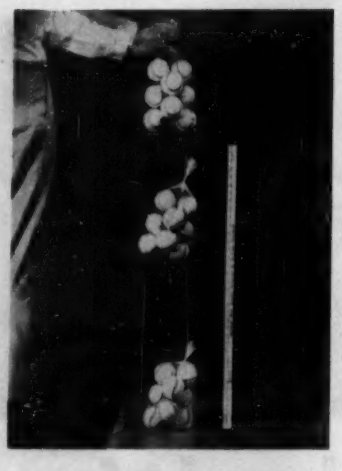
For year after year of *extra* service life, Lapp Pulsafeeders continue to give you the exclusive advantages for which you bought them. Advantages like complete freedom from leakage and contamination; precision metering, at flow rates from a few drops to 15.7 gallons per minute; pressures up to 7000 psig; choice of heads for safe handling of acids, abrasive slurries, radioactive fluids; manual or instrument controls. We've got a new catalog to help you fit the right model to your process.

Lapp

***WRITE** for Catalog 59. Lapp Insulator Co., Inc., Process Equipment Division, 1108 Poplar Street, LeRoy, N.Y.*

CHEMICAL PRODUCTS EDITED BY N. P. CHOPEY

What's New in Plastic Films . . .



. . . Transparency Plus Toughness

Another polyethylene film, produced by an improved mechanical process, has just entered the crowded packaging arena.

In several bag drop tests, including the one shown, the new film withstands 25% more drops than existing high impact films of the same thickness. It has higher gloss readings and 150% more impact strength than "high clarity" types. Special surface treatment permits a strong ink-film bond and enhances printing quality.

Marketed for bag-making and make-and-fill equipment, the film has a working temperature range (130 F. down to —60 F.) that suits frozen food applications.

Start-up of Du Pont's Richmond, Va., film plant began in June and production is expected to exceed 30 million lb./yr. One pound of plastic yields 30,000 sq. in. of 100-gage (1-mil) thickness film.

It comes in 100-, 125-, 150- and 200-gage thickness. — E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. 76A

. . . Low Vapor Absorption

This moisture repellent and shock resistant fluorohalocarbon film is the latest of 100 new fluorochemical products and materials developed by Allied Chemical.

Reportedly, in order to match the low vapor absorption of this new plastic a polyester film would have to be over 700 times thicker. Called Aclar, these fluorohalocarbon films resist the attack of almost all inorganic chemicals including the most corrosive acids and bases, and retain their flexibility over a 700-deg. temperature span from —320 F. to 390 F.

Current use is limited to packaging of delicate electronic and mechanical equipment parts where transparent Aclar films eliminate costly opening and rewrapping operations that occur in periodic military inspections.

Now available in pilot plant quantities, Aclar is scheduled for commercial production as soon as Allied's resin plant at Baton Rouge, La., goes on stream.— Allied Chemical Corp., New York. 76B

Alloy

New material improves alumina applications.

Fernico-5, a new alloy recently developed by General Electric, solves the problem of weak, cracking and short-lived metal-to-ceramic seals. This iron-nickel-cobalt alloy (no ratio given) provides the desired low thermal expansion because its ferromagnetic properties have been optimized by a melting process.

Apparently the vacuum process allows melting without addition of other oxygen-controlling elements such as manganese or silicon whose presence usually gives undesirable expansion characteristics to the finished product. Besides, im-

Nosey,
The Esso Solvents Expert, licks a pinholing paint problem with SOLVESSO®
The foreman had problems. Paint pinholed, blistered and pimpled. Those surface coatings looked terrible!
GLOOM!
I told him that SOLVESSO could help relieve these production headaches by controlling the evaporation better.
"Sounds great", he said. (He was also glad to learn that Esso is a pioneer in better odor solvents —and that Esso has a staff of experts in its refineries dedicated to the continuing improvement of solvents.)
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Just look at this lustrous finish... helped by SOLVESSO. For fast, dependable service (and quality solvents)—contact your nearest Esso office. (And tell 'em Nosey sent you!)
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proved control of iron-nickel-cobalt ratio is possible under vacuum melting and gives the desired crystal structure. Low gas content of Fernico-5 is an added attraction.

Up to now alumina's high heat resistance, strength and excellent insulating properties could not be fully exploited in making metal-to-ceramic seals. Most metals and alloys normally used in such seals were either expensive or invariably had a thermal expansion higher than alumina.

Ceramic-to-metal seals are used in electron tubes, thermionic energy converters, capacitors, switchgear and high-temperature circuits. — **General Electric Co., Schenectady, N. Y. 76C**

Explosive

Primer provides increased safety at reduced cost.

Specifically designed for ammonium nitrate-fuel blasting agents, this new Saf-T-Boost primer initiator requires no tieing, splicing or taping, and is suitable for decking, stemming or any other blasting technique. Firing of primer neatly severed the center section from the above ½-in.-thick hot-rolled steel plate.

Combined with 29 lb. of ammonium nitrate-oil mixture, Saf-T-Boost is claimed to replace with equal or better results a 30-lb. dynamite primer for less than half the cost.

Freezing temperatures do not affect the primer's hypersensitivity and it withstands the roughest treatment without detonating.

Packaged in a cardboard container, the new primer-initiator weighs 13 oz., and is 3 in. dia. by 2 in. high, and delivers a detonation velocity of over 20,000 ft./sec. assuring positive initiation each time.—**Propellex Chemical Div., Chromalloy Corp., Edwardsville, Ill. 78A**

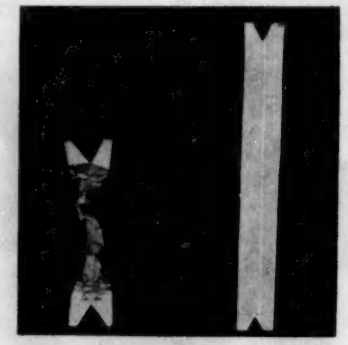
Fuel Oil Additive

New detergent improves engine performance.

After extensive tests, a specialized detergent fuel oil additive that promises to boost the life of diesel injector systems is now available for the first time.

The additive, called OFA 265, is a mixture of compounds that provide protection from gum and rust.

In one test, tank trucks covered up to 165,000 mi. and injector life was boosted by 63% with the average replacement interval increasing to 70,000 mi. In addition, the smoke level produced was equivalent to that of a clean reconditioned injector for distances up to 50,000 mi. **Oronite Chemical Co., San Francisco. 78B**



Palladium Alloy

New doors are opened for commercial hydrogen purification.

Unlimited stability is reported to be the outstanding characteristic of the palladium alloy shown above on the right. The badly deformed piece of pure palladium on the left had originally the same size and shape as the palladium alloy.

Newsworthy Chemicals

Page Number is also Reader Service Code Number

Polyethylene film combines transparency with strength.. **76A**
Fluorohalocarbon films for low temperature absorption.. **76B**
New alloy matches thermal expansion of alumina..... **76C**
Primer for blasting agents promises reduced costs..... **78A**
Fuel oil additive boosts engine performance..... **78B**
Palladium alloy used for hydrogen purification..... **78C**
Fire-retardant enamel resists corrosion..... **80A**
Reactone dyes present high solubility and stability..... **80B**
Alkyl aluminum catalysts for polymerizations available.. **80C**
Epoxy-based ink shows heat and solvents resistance.... **80D**
Starch phosphates applications multiply..... **80E**
Semi-silica refractory bricks resist loads and spalling... **80F**
Corrosion inhibitor protects metal surfaces from humidity **80G**
Pyromellitic acid ready for customers..... **80H**

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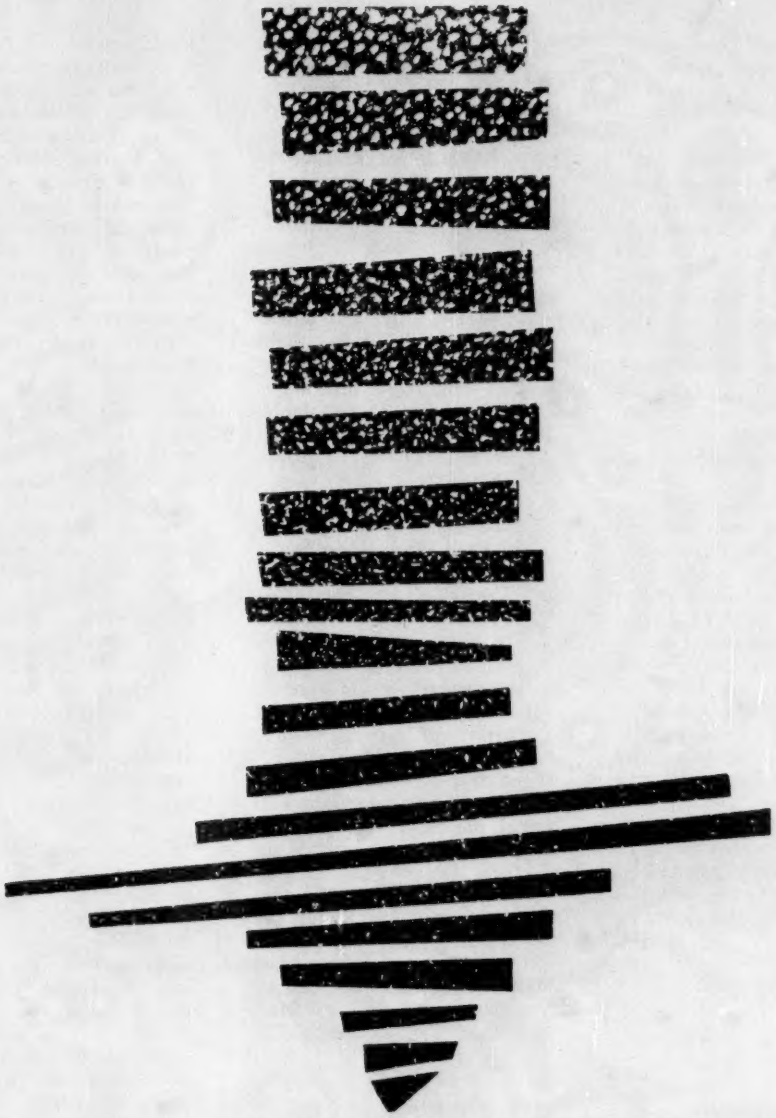

exploring the Sub-Micronosphere

The Sub-Micronosphere is the mystifying and challenging province of the small dust and fume particle, the "Submicron," which never exceeds 1/25,000" in size. Submicrons are elusive, wily and extremely difficult to capture... unless you use the right technique. Conquerors of the Sub-Micronosphere have found the Ducon Oriclone Scrubber to be a most effective weapon. It has captured Submicrons by the millions. The Oriclone is a new type of high energy scrubber... smaller... more economical... yet more effective than other units. It is the ideal collector for fine dusts and fumes.

Ask for Bulletin W-8560 and learn more about the Oriclone.

the name in Dust Control

THE Ducon COMPANY, Inc.

147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

Canadian Branch:

THE DUCON COMPANY, of CANADA, Ltd., 1121 Petrie St., BURLINGTON, ONTARIO, CANADA

Both strips have been alternately heated and cooled in hydrogen the same number of times and to the same temperature.

The new alloy selectively separates ultrapure hydrogen from gas mixtures and presents other advantages over pure palladium. It is more than two times as permeable to hydrogen, costs less, lasts longer and doesn't require special handling during start-up or shut-downs. X-ray diffraction studies have shown that the effect of the alloying element stabilizes the metal lattice so that atom distances are not changed during exposure to hydrogen.

Pure palladium as diffusion element for hydrogen separation or purification requires either the complete removal of hydrogen from both sides of the element before applying heat, or maintaining the temperature of the unit above the critical temperature. Lattice deformations are generally assumed to result from phase changes during hydrogen absorption but the behavior of the system is not entirely understood.

The alloy is now available in the form of diffusion cells in sizes for laboratory, pilot-plant and commercial hydrogen purification units.—**J. Bishop & Co., Malvern, Pa.** 78C

BRIEFS

Fire retardant enamel for use on previously painted or primed metal bulkheads and other interior surfaces is now marketed as HET® Acid. The important advantage over existing fire-retardant paints is that mineral spirits can be used as thinners instead of the relatively more toxic xylene and turpentine. Chlorendic acid is the key ingredient that makes possible corrosion-resistant alkyd coating with fire retardance. — **Hooker Chemical Corp., Niagara Falls, N. Y.** 80A

Reactone dyes provide an extremely useful range of reactive colors for padding as well as for textile printing. All dyes possess excellent solubility (200 g./l. or over). Solutions made alkaline with caustic soda or soda ash remain stable for several weeks without loss of color strength. —**Dyestuffs Div., Geigy Chemical Corp., Ardsley, N. Y.** 80B

Alkyl catalysts, tri-n-propyl, butyl, hexyl, octyl and triisohexylaluminum for olefin polymerizations and production of important intermediates will soon be available. Texas Alkyls recently began semicommercial production, and this is believed to be the first time that these compounds have been made in other than research quantities. — **Anderson Chemical Div., Stauffer Chemical Co., New York.** 80C

Epoxy-based marking ink eliminates smeared stencil information and resists effects of a variety of cleaning solutions such as xylene, chlorothene or methyl alcohol. Mel-Ink M-100 can be applied to metal, plastics, glass or wood. Markings are color-stable on surfaces exposed to temperatures up to 260 F. for the white ink and 350 F. for the black. They also satisfy requirements for permanence of MIL-STD-130 without use of a protective coating.—**Melpar, Inc., Falls Church, Va.** 80D

Starch phosphates production in research quantities has been announced. Known as esters formed from cornstarch and a blend of acid phosphate salts, this new group of products has greater thickening power than the cornstarch it is made from. Ore refining, water treatment, adhesives and cosmetics are other potential uses in nonfood industries. Commercial quantities expected by year end. — **American Maize-Products Co., Hammond, Ind.** 80E

Semi-silica refractory bricks for continuous service at operating temperatures up to 2,600 F. or more in metallurgical and ceramic furnaces are now available and sold under the name of Sem-Sil. Volume stability, resistance to structural spalling and unusual load-bearing ability at high temperatures are some of the features of these new bricks. Principal applications are in roofs of hot metal mixers, sidewalls of open hearth regenerators, blast furnace stove domes and periodic kilns. — **H. K. Porter, Inc., Pittsburgh.** 80F

Corrosion inhibitor for copper and brass, added to rinse water, preserves freshly plated or cleaned metal surfaces during storage. One gallon of this neutral solution called Entek CU-56, diluted with water to 1%, will treat approximately 500 sq. ft. of metal surface; immersions of 5 to 30 sec. protect against 200 hr. of tropical humidity. Adhesion of lacquers and enamels improves after rinsing. — **Enthone, Inc., New Haven, Conn.** 80G

Pyromellitic acid (PMA) and pyromellitic dianhydride (PMDA), two new chemical intermediates, are now in commercial production in Gibbstown, N. J. A multimillion-lb./yr. production unit has made possible substantial price reduction for both compounds. PMDA can be used in synthesis of high-temperature lubes and plasticizers, as a component of polyester and alkyd resins, and in polymer preparations. PMA can be used interchangeably in some of these applications. —**E. I. du Pont de Nemours & Co., Wilmington, Del.** 80H

For More Information

about any item in this department, circle its code number on the

Reader Service

postcard (p. 185)

UNRULY UREA TOES THE LINE FOR 6 SOLID YEARS

Another demonstration of how well Aloyco Valves withstand the worst kind of corrosive conditions... many more years of service are expected. That's why engineers at Deere & Company's giant $20 million Oklahoma plant (went on stream in 1954) put many more Aloyco Valves to work. They buy performance. You'll find Aloyco Stainless Steel Valves in scores of processing plants, wherever severe conditions present difficult valve problems. Want to know more? Write: Alloy Steel Products Co., Inc., 1301 West Elizabeth Ave., Linden, New Jersey. o.2

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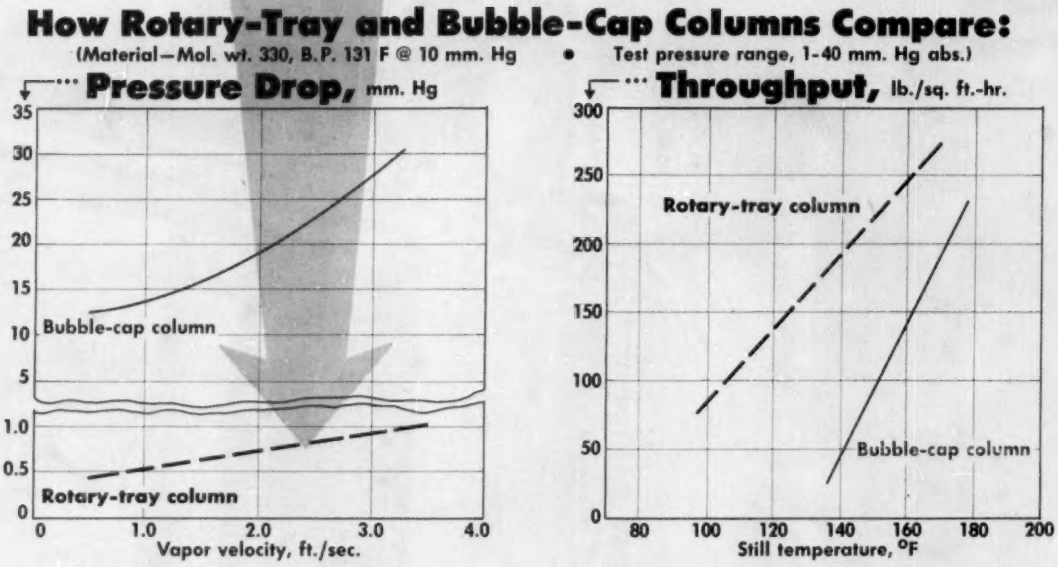

Take the Pressure Off Distillation Columns

European processors benefit from column which uses rotary instead of bubble-cap trays, gives low pressure drop for high throughput. Column will be available in U.S. soon.

Materials which require minimum heat exposure or reduced temperature during distillation —hence need low absolute pressure—can now be kid-glove processed in a new column which has an amazingly low pressure drop of about 1 mm. Hg. It's not a puny laboratory column, but a full-scale commercial unit

To eliminate pressure drop, the column's designers had to depart from conventional means of obtaining vapor-liquid contact, such as bubble-cap trays or internal packing. The radical new design achieves contact by a series of rotating trays which fling liquid reflux droplets from the column center to the wall. Rising vapor, passing through the liquid curtain, contacts the liquid intimately, just as it does on conventional trays.

▶ **European Design** — Invented by Sweden's Stora Kopparbergs Bergslag A.B., the columns have seen extensive service in Europe, distilling tall oil, caprolactam, and other undisclosed materials. Stora has licensed Vulcan-Cincinnati to build and distribute the towers in U.S. V-C is currently working with an unidentified firm for the tower's first U.S. application.

It's easy to see from an energy balance how the new column cuts pressure drop. In a bubble-cap unit, the uprising vapor must push its way through a layer of liquid on every tray. This bubbling action, essential for vapor-liquid contact, requires energy which is generated by heat input (and pressure) in the bottom of the column.

In the rotary tray unit, energy for the contact is provided by the rotor, which is driven by an external motor. Result: less heat

Highest toluene dilution ratio

with National® NADONE®

(CYCLOHEXANONE)

One of the most powerful solvents available at a volume-production price, NADONE Cyclohexanone can cut the overall cost of solvent systems for organic coatings.

The addition of a small percentage of NADONE permits an increase in the volume of diluent that can be successfully incorporated in the solvent system. In nitrocellulose lacquers, for instance, NADONE solutions have a 6.3 toluene dilution ratio. Comparably high ratios obtain for other resins and diluents.

Conversely, NADONE solvent power makes possible higher solids content in resin-solution formulations.

An added advantage: Inclusion of NADONE prevents separation of resins and oils in solution and during evaporation of solvent from the film.

*U.S. Patent 2,389,608

Other interesting, cost-saving uses of NADONE are:

- As a detergent-additive in lube oils to minimize carbon and sludge formation.*
- To improve fractional solvent extractions.
- As a degreasing solvent or fortifier for lower-power degreasers.
- To make better paint removers, inks, adhesives, pesticides, etc., etc.

WRITE FOR TECHNICAL BULLETIN 1-19C

This 32-page bulletin gives details on these and other applications of NADONE, contains complete properties, reactions and a valuable list of 148 literature references. We'll gladly send you a copy of this bulletin and, if you wish, a liberal working sample of NADONE for your investigations.

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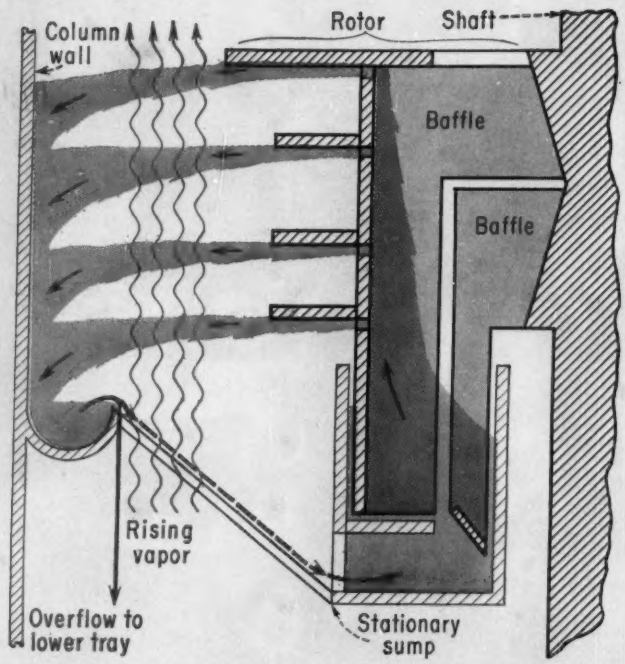


ARTIST'S CONCEPTION of rotary tray traces the path liquid follows during a cycle. Slots which direct liquid from rotor to wall have a staggered spacing, but rapid whirling of the cylinder produces a series of complete liquid curtains through which the uprising vapor must pass.

input, lower temperature and pressure in the column bottom. Rotary-tray column is most effective in the pressure range of 1-20 mm. Hg absolute.

► **Round and Round**—Let's take a typical rotor tray and see how it works. Think of the tray as consisting of two main elements —a liquid-holding system which is stationary, and the rotor which revolves. Assume that the tray is in operation, so it is already filled with liquid.

As the rotor turns, a series of paddles push the liquid outward centrifugally and a slanted baffle carries it upward against an outer slotted cylinder. This rotating cylinder is slotted in a regular pattern to let the liquid through in a thin curtain of droplets.

Above each slot on the outside of the cylinder is a baffle which guides the droplets in a horizontal path to the wall. The liquid must have no upward motion as it traverses the upflowing vapor stream or droplets may be carried up into the next rotor tray, destroying tray efficiency.

► **Collect and Split**—After the liquid has passed through the vapor and impinged on the wall, it flows down into the tray's collecting trough around the periphery of the column. Once collected, part overflows to the next lower tray and part flows back into the stationary sump for another trip through the rotor.

The passages which carry the recycle to the center are like the spokes on a wheel, with large open spaces between them for the free passage of vapor.

► **The Comparison** — Comparative data for bubble-cap and rotary-tray columns shown on the first page for comparable 10-tray columns was obtained from Muller-Schuss Kg., German manufacturer of the columns. Rotor design in the European columns is a little different from that described here, but the principle is the same.

Muller-Schuss builds columns from 20-in. I.D. with 15 rotor trays to 55-in. I.D. with 10 trays. A 39-in., 10-tray stainless steel column would cost about $15,000, according to M-S. Vulcan-Cincinnati has not said when the American version described above will be available.—**Vulcan-Cincinnati, Inc., Cincinnati, Ohio.** 82A

Furane Plastic Pipe

New line withstands hot corrosives up to 300 F.

A new furane plastic pipe is now available for general corrosive service. Named Eonite, this pipe is made of Durez 16470 resin reinforced with woven borosilicate glass, which has better strength and chemical resistance than electrical glass fabric also used with furane resin.

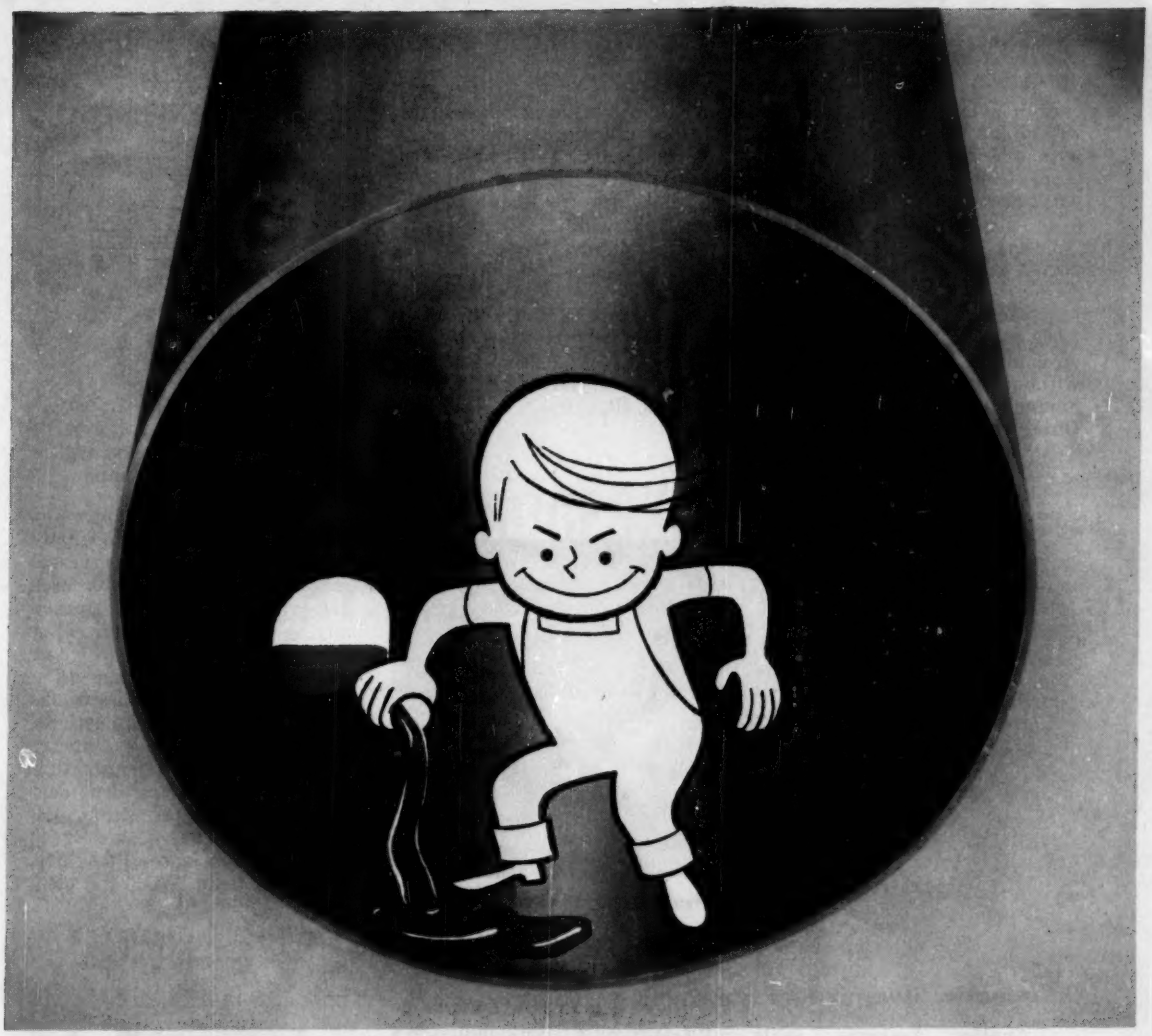
Available in 15-ft. lengths, the pipe can be cut in the field with a hack saw and installed with a screwdriver and a wrench. Joints are made up with cast-iron flanges, tapered rings and a hard asbestos gasket impregnated with neoprene and graphite. No cements or solvents are used.

Ranging from 2- to 12-in. I.D., pipe costs $3.45 to $15.40/ft. Rigid up to 300 F., it withstands pressures to 150 psi.—**Cornelius A. Rauh & Associates, Akron, Ohio.** 84A

Steel-Armored Hose

Inner core of seamless nylon has tough cover.

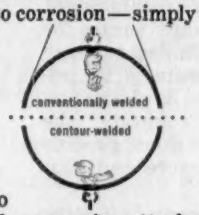
New steel-armored hose is very resistant to fire, heat and mechanical damage, according to the manufacturer. Hose is built in four layers—a central



"The Gravity Kid" shows how

CONTOUR-WELDED STAINLESS TUBING DEFIES CORROSIVE ATTACKS

It's smoother inside than any other tubing—welded or seamless—because the patented* Contour-welding process virtually eliminates the weld bead. And this smoother surface ensures greater resistance to corrosion—simply because there are fewer focal points for corrosive attack.



You see, in conventionally welded tubing, gravity pulls the molten metal down into the tubing. This forms a bead that is difficult to remove by cold working. And cold working can lead to undercuts that become focal areas for corrosive attack.

Contour-welded tubing, however, is welded at the bottom. Gravity still pulls the molten metal down. But now the weld area corresponds to the contour of the tube. There's virtually no weld bulge on the inside surface. And even on the O.D., the weld seam closely conforms to the tubing contour.

Contour-welded tubing is smoother, too, than seamless. That's because it's formed from uniformly rolled strip steel whereas seamless is extruded from a billet.

But get full details on this corrosion-resistant tubing. Send for our free 48-page manual on Contour-welded tubing in sizes from 1/8" to 40" O.D.—in stainless and high alloy steels, titanium, zirconium, zircalloy and Hastelloy.**

*U.S. Patent 2,716,692

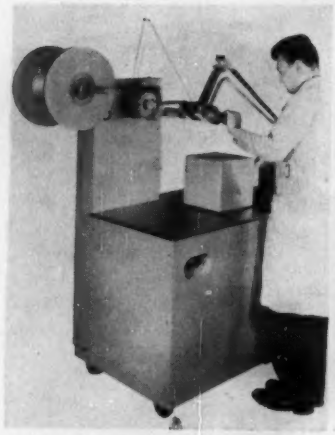
**Trademark Haynes Stellite Co.

TRENTWELD® Stainless and High Alloy Tubing

Trent Tube Company, a Subsidiary of Crucible Steel Company of America. General Offices and Mills: East Troy, Wisc.; Fullerton, Calif.

core of nylon tubing is covered with black vinyl and wrapped with Mylar-backed asbestos tape. Galvanized steel armor, 0.012-in. thick, completes the hose.

Called Synflex Hi-Temp, the hose safely delivered a flammable fluid during a test while immersed for 15 min. in a 2,000-F. flame. It also withstood an external pressure of 300 psi. without pinching off the flow.—**Samuel Moore & Co., Mantua, Ohio.** 84B



Automatic Strapper

Applies, tensions, seals rayon strap on packages.

New packaging machine, claimed to be the first automatic unit for applying rayon strap, can band up to 15 packages a minute with ½-in. wide strap. It adjusts for packages from 6 × 2 × 8 in. up to 18 × 36 by any length.

Tying tension, adjusted by a control knob on the front of the machine, can be set either for strapping compressible bundles or rigid cartons. Strap has a tensile strength of about 500 lb./in. width (or about 100 lb. for ½-in. width).

Strap is overlapped on the bottom of package and sealing jaws crimp a metal seal which is fed automatically from a 5,000-unit magazine. Strap feeds into the machine from 5,000-yd. spool.—**A. J. Gerrard & Co., Des Plaines, Ill.** 86A

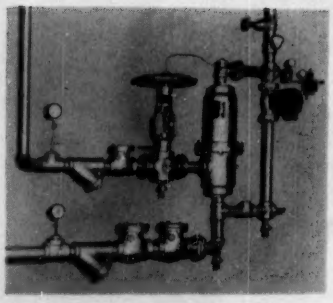
Pressure Regulator

Compact, light-weight unit works to 10,000 psi.

New regulators are available for pressure reducing, back pressure service, and combination pressure reducing and relief service. Dubbed Mity-Mite, regulators are of the gas-controlled dome type which operate on the principle of balanced pressure with the valve action controlled by a pressure reaction chamber.

In this type valve, seat wear and valve chatter are minimized since line pressure surges or sudden changes in flow rate are opposed by pressure in the reaction chamber. A restricting orifice which connects the chamber with the dome governs the rate of pressure equalization.

Pressure reducers, ¼- to ½-in., accept inlet pressures of 10,000 psi., adjustably control to 6,000 psi. Back pressure unit, ¼-in., holds up to 3,000 psi.—**Grove Valve and Regulator Co., Oakland, Calif.** 86B

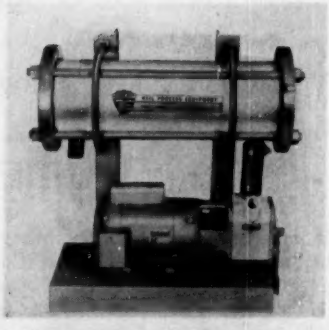


Water Heater

Low-pressure steam makes hot water on demand.

Need hot water, intermittently or continuously, to supply a heat exchanger or a vessel jacket? New water heater uses low-pressure steam in patented mixing chamber to generate hot water as it's needed. No water drawn, no steam consumed.

Requiring no storage tanks and only three pipe connections, heater operates on 5-psi. steam, controls water temperature within 3 deg. during both continuous and intermittent hot water withdrawal. Can be used for lavatories, too.—**Pick Mfg. Co., West Bend, Wis.** 86C



Heat Exchanger

Impervious-graphite model has circulating pump.

Practically any acid can be handled with a new impervious-graphite Series 1231 heat ex-

For More Information

about any item in this department, circle its code number on the

Reader Service

postcard (p. 185)

EQUIPMENT NEWS Continues on . . . **Page 169**

Beginning a new series . . .

A CHEMICAL PROCESSING INDUSTRY FILE

In order to help chemists, engineers, and management men in keeping up with the frequent changes that occur in the chemical processing industry, Dow is instituting a product information series . . . Dow CPI Files.

It is the purpose of this new series to make product information more useful to those concerned with chemical processing. Instead of presenting new chemicals as isolated items, this series will present products as they are related to classes of processing problems.

Sometimes these products will be new, or newsworthy. Sometimes they will be established products with new or continuing relevance to today's problems. Always they will be presented in their relation to a particular area of interest to processors.

EMULSIFICATION

Dow products relating to emulsification will be covered in this first series of advertisements. On the next page, the first ad in the series describes alkanolamine soaps as emulsifiers, and methylcellulose as a thickener and surfactant. Later advertisements will present other emulsifier intermediates and additives, plus new Dow emulsifiers soon to be announced.

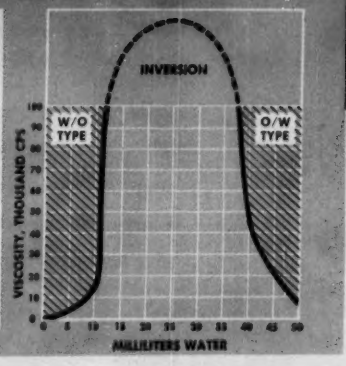
DOW | **THE DOW CHEMICAL COMPANY** • Midland, Michigan

Dow **C.P.I.** *file* **1**

EMULSIFICATION

PRIMARY CONSIDERATIONS in the choice of emulsification materials are compatibility of the components, viscosity, stability, particle size, and toxicity. On the next page are shown the properties of methylcellulose, a highly effective, safe emulsifier. Described below is a formulating technique with Dow alkanolamines contributing to higher viscosity, smaller particle size, and thus greater stability.

INVERSION, the technique by which the oil and water phases of an emulsion change relationships, is recommended for use in all methods of alkanolamine emulsion formulating when maximum stability is desired. Graph shows changeover of a triethanolamine emulsion. The fatty acid was dissolved in the oil and the TEA was dissolved in the resulting acid-oil solution. Then, with stirring, small increments of water were added. The graph is characteristic of all alkanolamines if the same procedure is followed.



INTERMEDIATES

ALKANOLAMINE SOAPS—NONCORROSIVE, STABLE, SAFE FOR SKIN AND TEXTILES

MOST IMPORTANT of the Dow alkanolamines, all water soluble, are monoethanolamine (MEA), triethanolamine (TEA), monoisopropanolamine (MIPA), and diisopropanolamine (DIPA). Compared to other amines in the alkanolamine series, these compounds produce emulsions having finer particle size and greater stability.

Being essentially neutral, emulsions prepared with alkanolamines are relatively noncorrosive to metals and are not harmful to the skin nor to textiles. Frequently a natural oil will contain enough organic acid so that in the presence of an alkanolamine it will emulsify readily in water. Alkanolamine-fatty acid emulsions are easily prepared from such common acids as oleic, stearic, and palmitic. End use will determine the acid used. For example, oleic acid yields low viscosity, stearic higher viscosity. Proven uses for alkanolamine soaps include metal cutting and buffing compounds; floor, furniture, and car polishes; pharmaceutical ointments, skin creams and lotions; insecticide sprays, textile scouring, and wetting agents.

For a comprehensive coverage of the Dow alkanolamines, write for the Dow booklet "Alkanolamine Soaps in Emulsions."

CHOICE OF FATTY ACID HAS STRONG EFFECT ON EMULSION VISCOSITY		CHOICE OF AMINE HAS LESS EFFECT ON EMULSION VISCOSITY	
FATTY ACID	VISCOSITY (cps) at 77°F.	AMINE	VISCOSITY (cps) at 77°F.
Oleic	240	DIPA	3.9
Palmitic	450	MIPA	8.0
Stearic	2,000	MEA	12.0
		TEA	230.0

Mineral oil and water dispersions in 1:1 fatty acid-alkanolamine mole ratio of components. Table 1 at left uses TEA as the amine, Table 2 at right uses oleic acid. Both systems contain approximately 80 parts water, 15 parts oil, and 7.5 parts total emulsifier.

THICKENER

UNIQUE THICKENER HAS SURFACTANT PROPERTIES, EXEMPT FDA STATUS

Methocel®, Dow methylcellulose, is an outstanding example of a synthetic methylcellulose gum that excels natural gums as a thickener and has valuable side properties as well. In addition to thickening, Methocel products are used as emulsifiers, emulsion stabilizers, suspending agents, and binders.

Methocel compounds are also unique in the class of gum compounds for their *surfactant* properties. Lowering the surface tension of water, Methocel is classed as a moderately active wetting agent. In many formulations Methocel acts as both thickener and surfactant.

ORGANIC COMPATIBILITY. One of the Methocel products—60 HG—differs from other synthetic or natural gums because of its solubility in both water and in organic solvents. High organic compatibility suggests its use for emulsifying a variety of aromatic and other organic materials. Another—Methocel 70 HG—has provided the answer to some of the problems encountered in the preparation of straight-chain hydrocarbon emulsions.

APPROVED FOR FOOD USE. Methocel products have been used as food additives for many years. Methocel MC, U.S.P., is generally recognized as safe for use in foods (*Federal Register*, 881, February 2, 1960). A food additive petition has been filed (No. 72) covering the use of the Methocel HG products in foods (*Federal Register*, 1690, February 26, 1960). Current use of the Methocel HG products is permitted under an extension of the effective date of the statute to March 6, 1961 (*Federal Register*, 1071, February 6, 1960).

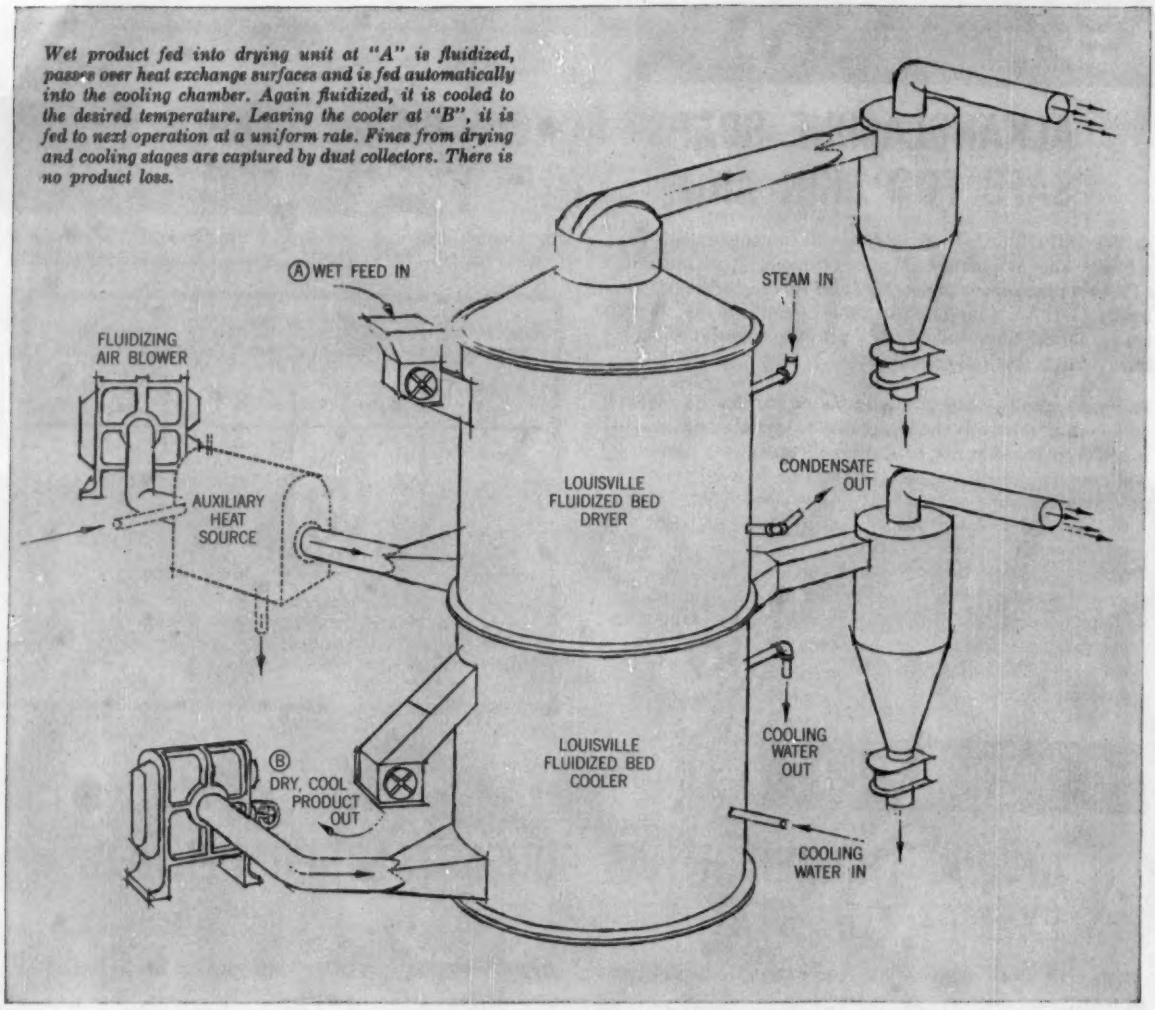
LATEX THICKENER. Methocel products work exceptionally well with latexes as viscosity control agents, stabilizers, and plasticizer dispersants. Other uses for Methocel with latex are for adhesives, paper and textile coatings, dipped rubber goods, and paint.

NEW GRANULAR FORM. A free-flowing, dust-free granular form of Methocel permits dispersion in cold water without lumping. It is especially useful in latex paint manufacture.

The Dow Chemical Company, Midland, Michigan
Chemicals Merchandising Dept. 425AK8-8.
Please send me information on—Dow Alkanolamines ☐
Methocel—
for food ☐ for drugs & cosmetics ☐ for chemical processing ☐
Name_____
Position_____ Company_____
Address_____
City_____ Zone____ State_____

DOW

THE DOW CHEMICAL COMPANY
Midland, Michigan


Wet product fed into drying unit at "A" is fluidized, passes over heat exchange surfaces and is fed automatically into the cooling chamber. Again fluidized, it is cooled to the desired temperature. Leaving the cooler at "B", it is fed to next operation at a uniform rate. Fines from drying and cooling stages are captured by dust collectors. There is no product loss.
Ⓐ WET FEED IN
STEAM IN
FLUIDIZING AIR BLOWER
AUXILIARY HEAT SOURCE
LOUISVILLE FLUIDIZED BED DRYER
CONDENSATE OUT
LOUISVILLE FLUIDIZED BED COOLER
COOLING WATER OUT
Ⓑ DRY, COOL PRODUCT OUT
COOLING WATER IN

Major break-through in drying and cooling techniques announced by

GENERAL AMERICAN

A new system for drying and cooling has been perfected by General American Transportation Corporation through their development of Louisville Fluidized Bed* equipment. Two Louisville units, one functioning as a dryer and one as a cooler are coupled vertically to provide a continuous automatic operation.

The system is particularly useful for crystalline chemicals, resins, polyvinyl acetate beads, polyethylene pellets, sugar and similar products having the proper particle size distribution.

Louisville Fluidized Bed equipment offers these advantages:

1. Accurate, instantaneous temperature control
2. High heat transfer that permits compact design
3. Low maintenance costs (no moving parts)
4. Less cleaning time and labor
5. Less floor space (equipment is vertical)
6. No hot spots (product is fully protected)

Because of their simplicity, Louisville Fluidized Bed dryers and coolers adapt readily to complete automation.

For full details about this revolutionary development in drying techniques, write Dept. F.

Process Equipment Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street
Chicago 3, Illinois
Offices in principal cities

*Patents Pending

DeZURIK VALVES....

...so much to offer on any installation!

With their easy operation, dead tight shut off, freedom from lubrication and other maintenance, DeZurik Valves offer still more advantages to the processing plant where corrosion, erosion or contamination is a factor.

A wide variety of materials is available for plug facings and valve bodies, allowing an almost "custom-designed" DeZurik Valve.

Plugs can be faced with Neoprene, Hycar, Teflon, Hypalon, Viton and other compounds which offer resistance to the deteriorating action of most chemical services. Metal faced plugs are available for use on extremely high temperature services.

Valve bodies are available in semi-steel, bronze, acid resisting bronze, Ni-Resist, aluminum, carbon steel, ductile iron, stainless steel, Alloy 20, Monel, nickel and other alloys. They can also be supplied with plastic coatings and hard or soft rubber linings.

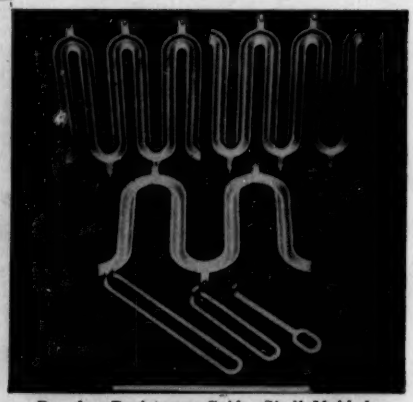
Whatever problems *your* applications present, there's sure to be a DeZurik Valve that will handle it easier, better, with less trouble, longer! Why not ask the DeZurik representative in your area, or write for details?

DeZURIK CORPORATION
SARTELL, MINNESOTA

Duraloy Tubes and Grids *to Meet Exacting* EF *Specifications*

THE ELECTRIC EF FURNACE
GAS • OIL • ELECTRIC

Duraloy Centrifugally Cast Tubes 7'9" long, 7" O.D., ⅜" wall. 28 Cr 10 Ni; some of HOM alloy.



Duraloy Resistance Grids—Shell Molded. 18 Cr 38 Ni; some of special HOM alloy.

Heat treating furnaces need high alloy castings... radiant heat tubes for gas or oil fired... resistance grids for electrical... and castings for handling material through the furnace. *And the castings must be fail-proof!*

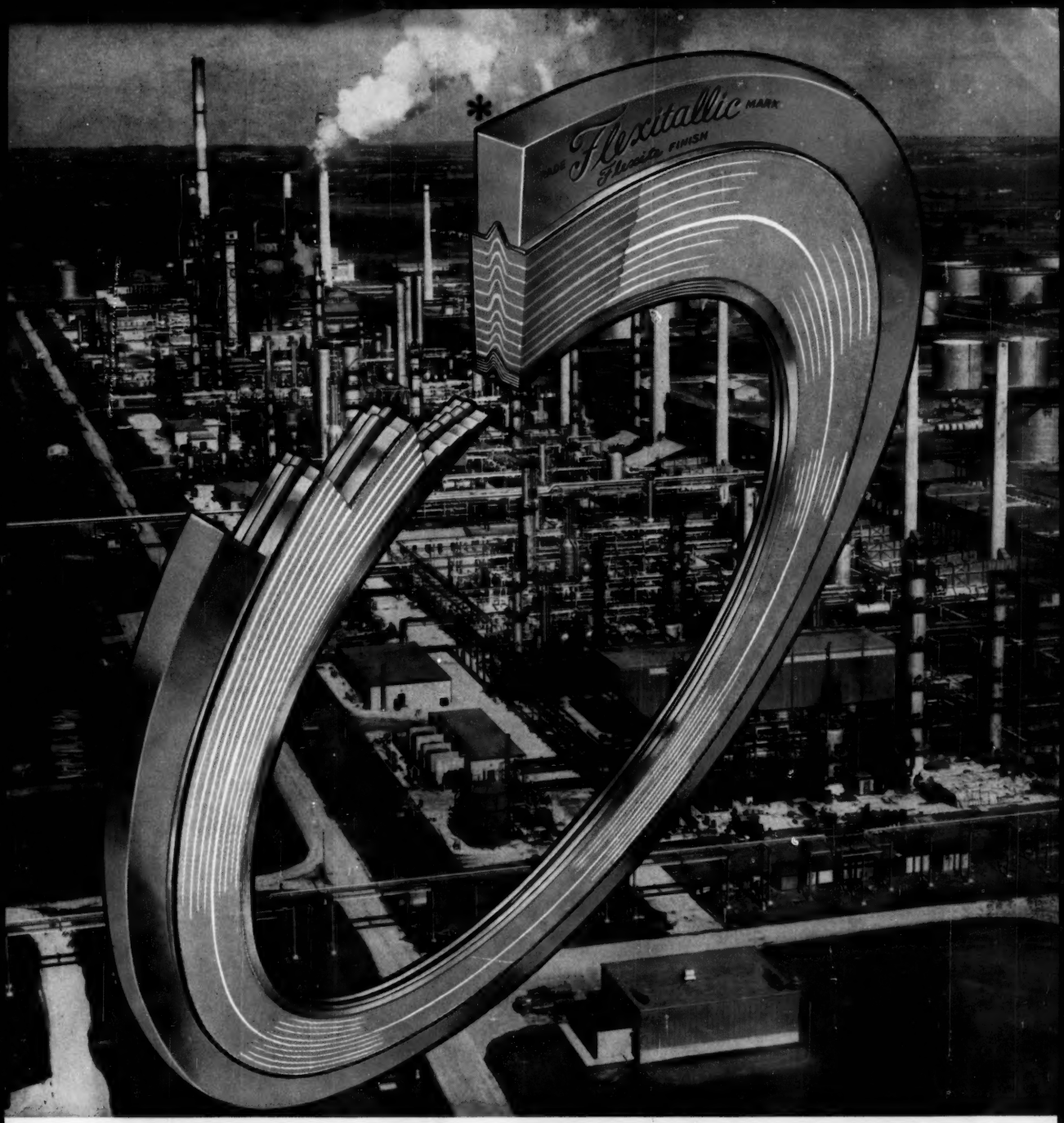
One reason—indeed the major reason—why The Electric Furnace Company, Salem, Ohio, has leaned so heavily on Duraloy for its castings is that over the years Duraloy Castings have established a fine record for durability and uniformity. And with the recent development of Duraloy HOM, the furnace company can work towards higher temperature operations. HOM can be used quite broadly at temperatures up to 2200°F and in a limited way to 2300°F. It can be cast statically, centrifugally and shell molded.

When such an authority on heat treating furnaces as Electric Furnace so consistently selects Duraloy castings for these furnaces on which it has built an enviable reputation... that preference suggests quite strongly that Duraloy castings are consistently sound and skillfully alloyed to meet exacting high temperature applications. This same skill offers comparable values to all who require high alloy castings.

Annealing furnace designed and constructed by The Electric Furnace Company used for cycle annealing of enameling iron strip and bright annealing of cold rolled strip. Three methods of heating: direct fuel fire; fuel fired radiant heat; and electric resistance used in the various zones.

DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.



End corrosion in gasket inventory

The gold Flexite Finish* for the metal gauge rings in Flexitallic Compression-Gauge Gaskets is new. It is highly corrosion resistant when exposed to severest weathering in open construction projects or in stock. The Flexite Finish provides for ease of identification and a clean, long-lived installation. Write for samples.

FLEXITALLIC GASKET CO., 8th & Bailey Sts., Camden 2, N. J.
Representatives in Principal Cities

TRADE Flexitallic MARK
SPIRAL-WOUND GASKETS
WITH Flexite FINISH

*The gold Flexite Finish is a development of the Flexitallic Gasket Co. (Originators of Spiral Wound Construction) — Register applied for on both name and color. Flexitallic Blue is our exclusive blue-dyed Canadian asbestos filler. Look for the blue and gold color combination as the mark of Flexitallic quality.

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

Seals of KEL-F® Brand Plastic remain flexible, can withstand 1,000 openings and closings at -320° F.

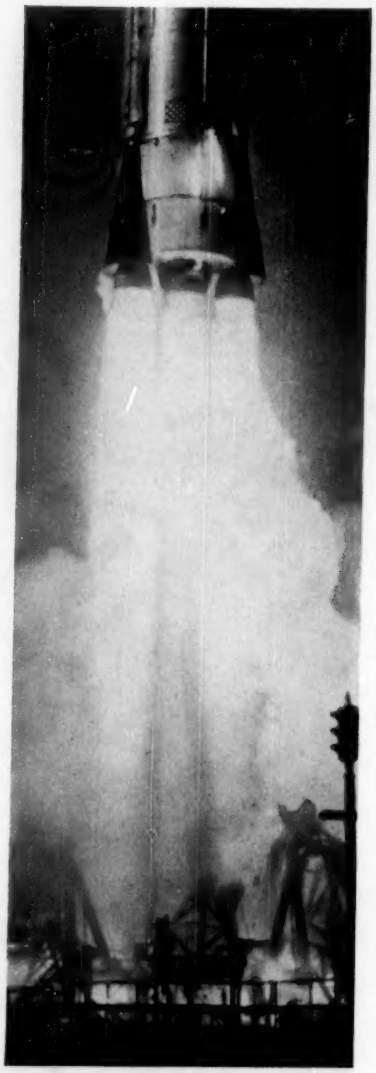
Clary Dynamics of San Gabriel, California, needed a very special kind of sealing material in their drain and fill valves. It had to withstand 1,000 opening and closing cycles and still remain flexible—and it had to withstand LOX at –320° F. Ordinary materials just wouldn't work. They became rigid with constant exposure to LOX . . . shattered under such extreme cold conditions.

The material that came closest to meeting all their requirements was KEL-F Brand Plastic from 3M Company.

Why KEL-F Plastic? It remains inert to flowing liquid oxygen, remains completely functional even after liquid oxygen has been standing in the valve for several hours. In addition, KEL-F Plastic has low cold flow, maintains its resilience at extremely cold temperatures and has relatively low coefficient of contraction at the cryogenic operating temperature. What's more, these seals, manufactured by the Raco Engineering of Los Angeles, can be molded on conventional equipment to any desired shape.

KEL-F Brand Plastic is ideally suited for many uses in the space age because it is thermally stable, impervious to the action of corrosive chemicals and highly resistant to most organic solvents. Also, it has zero moisture absorption, excellent flexibility and high impact and compressive strength. Among its many uses: LOX seals, valve diaphragms, flow meters and fuel bladders.

For complete performance characteristics, write today specifying area of interest to: 3M Chemical Division, KAL-80, St. Paul 6, Minn.



"KEL-F" is a Reg. T. M. of 3M Co.

CHEMICAL DIVISION

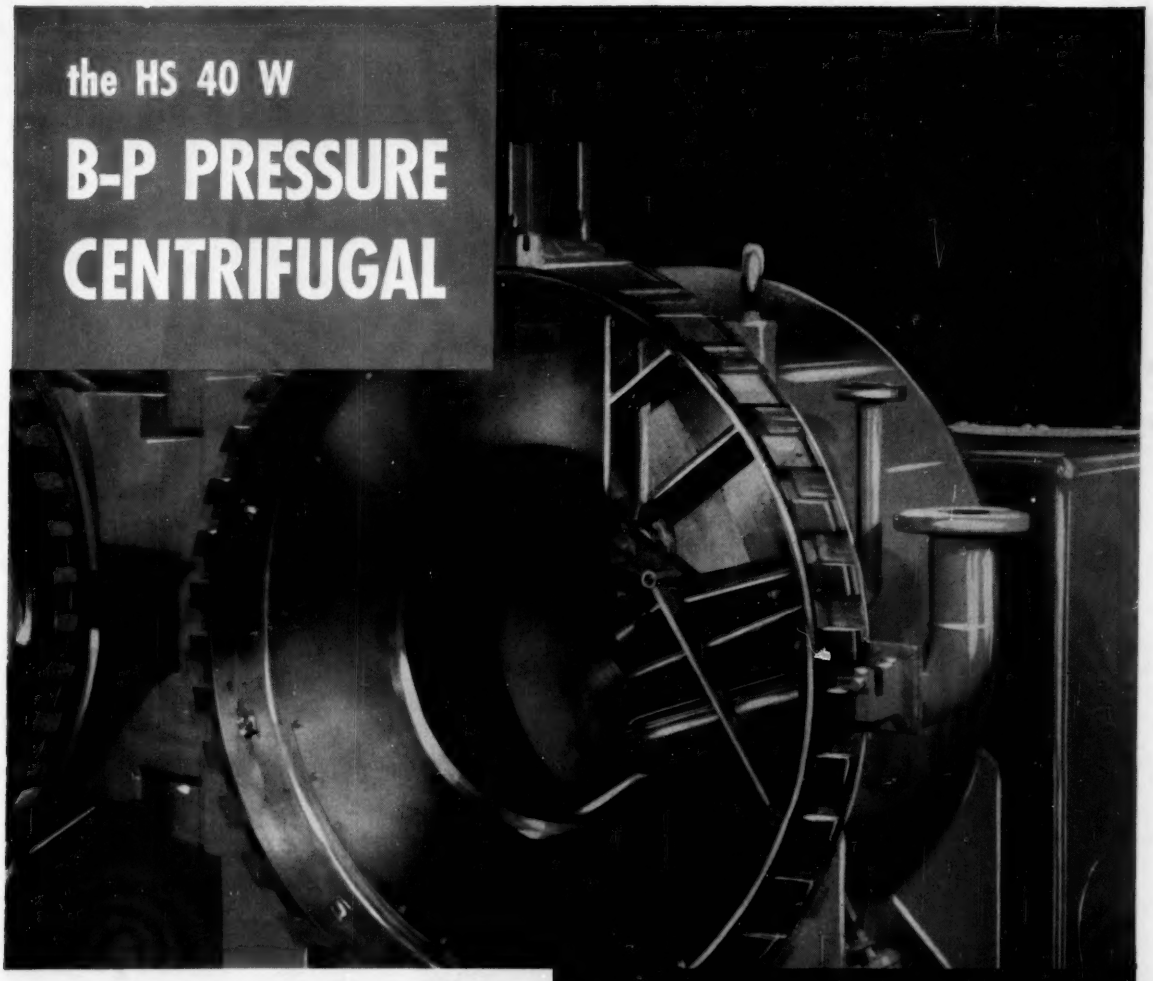
MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

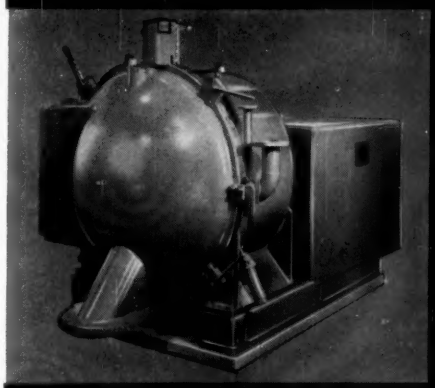
the HS 40 W

B-P PRESSURE CENTRIFUGAL



BAKER PERKINS research now brings you the HS 40 W Universal Pressure Centrifugal, engineered for normal operation at 1000 times gravity and internal pressures to 150 psi. Several important features are entirely new: A MECHANICAL SELF-BALANCING SHAFT SEAL is positioned where the main shaft enters the housing and is the only major moving seal. A CLAMPING AND SELF-ALIGNING DOOR SEAL consisting of a floating ring plus two O-rings assures a completely safe lock without the necessity of tightening bolts. A SIMPLIFIED DESIGN OF THE DISCHARGE KNIFE AND CHUTE. Complete discharge of all solids is effected, eliminating swirling or dusting of solids within the housing. PROGRESSIVE PEELING. For the first time, provision is made for the peeler knife to enter the cake at successively increasing depths. Glazing of the heel is eliminated. Air displacement is controlled during both the charging and peeling operations.

As in all Baker Perkins Universal Centrifugals, the interior of the new model is completely and readily accessible. For complete specifications of the high capacity HS 40 W Universal Pressure Centrifugal, see your B-P sales representative or write to:



BAKER PERKINS INC.

CHEMICAL MACHINERY DIVISION
SAGINAW, MICHIGAN

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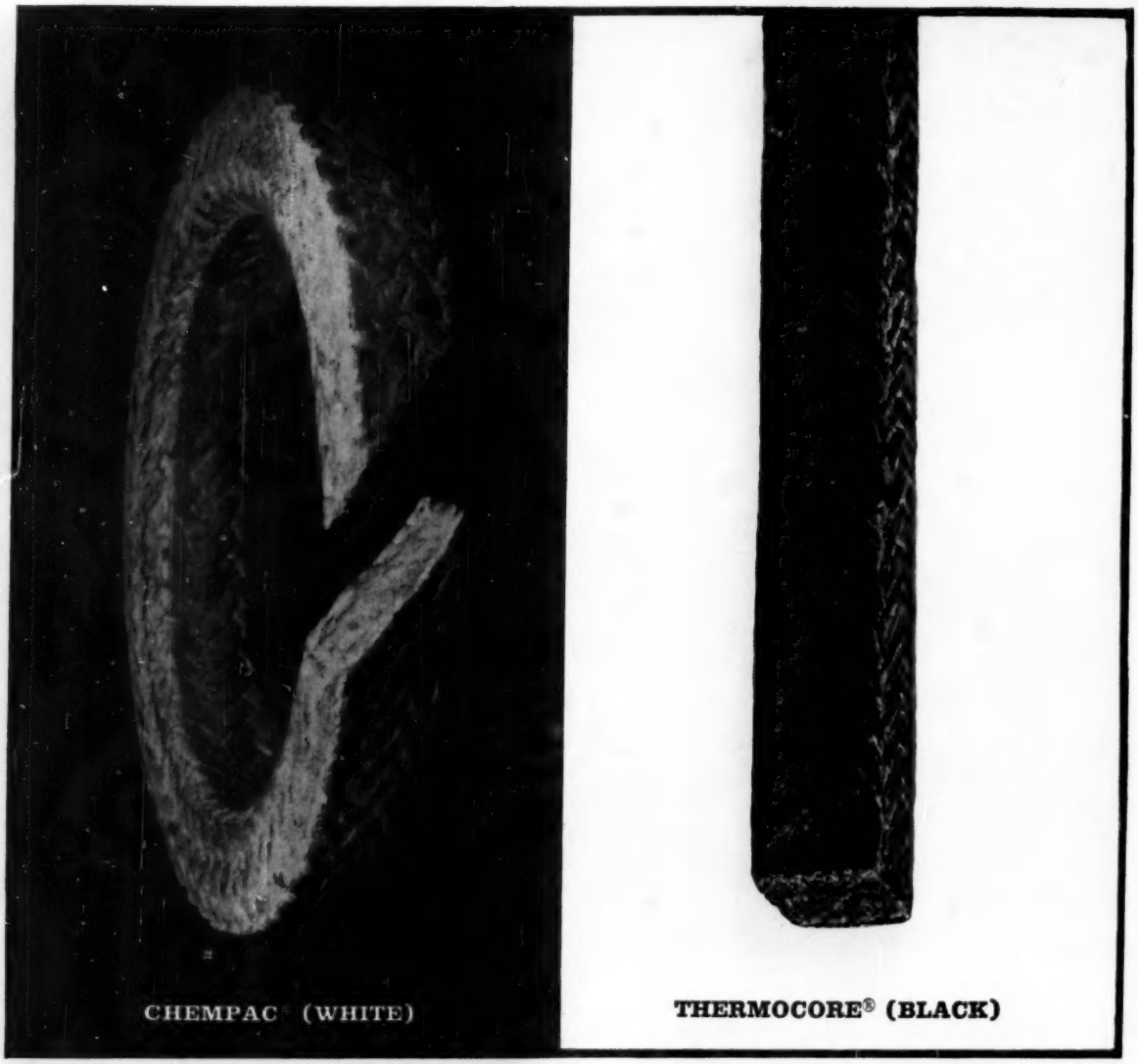


Now—just two J-M styles will handle 9 out of 10 mechanical packing problems!

LET VERSATILE "BLACK" OR "WHITE" HELP YOU REDUCE PACKINGS INVENTORY

Of Johns-Manville's many packing styles, two stand out as "all-purpose" packings. One is for pumps, the other for valves. These two packings not only do an outstanding sealing job . . . they also simplify your packings inventory investment to a minimum.

In 9 out of 10 cases, CHEMPAC and THERMOCORE will handle any pump or valve job in your plant!

CHEMPAC (white) combines the excellent sealing and heat-resistant qualities of asbestos . . . with Teflon's immunity to almost all chemical and solvent action. Chempac Style 2009 will give outstanding service on pumps, expansion joints and agitators.

THERMOCORE (black) consists of asbestos yarns, reinforced with Inconel wire . . . braided over a plastic core of graphite and 100% white asbestos. It remains stable even in valves where line temperatures run as high as 1200 F . . . adapts readily to eccentric motion. Thermocore Style 397 is recommended as the "universal" valve packing.

Johns-Manville produces the industry's most complete range of packing styles. These are described in a new 64-page Mechanical Packings book—the most complete of its kind. In its handy pages, you will find answers to the correct selection of packings best suited to each particular requirement.

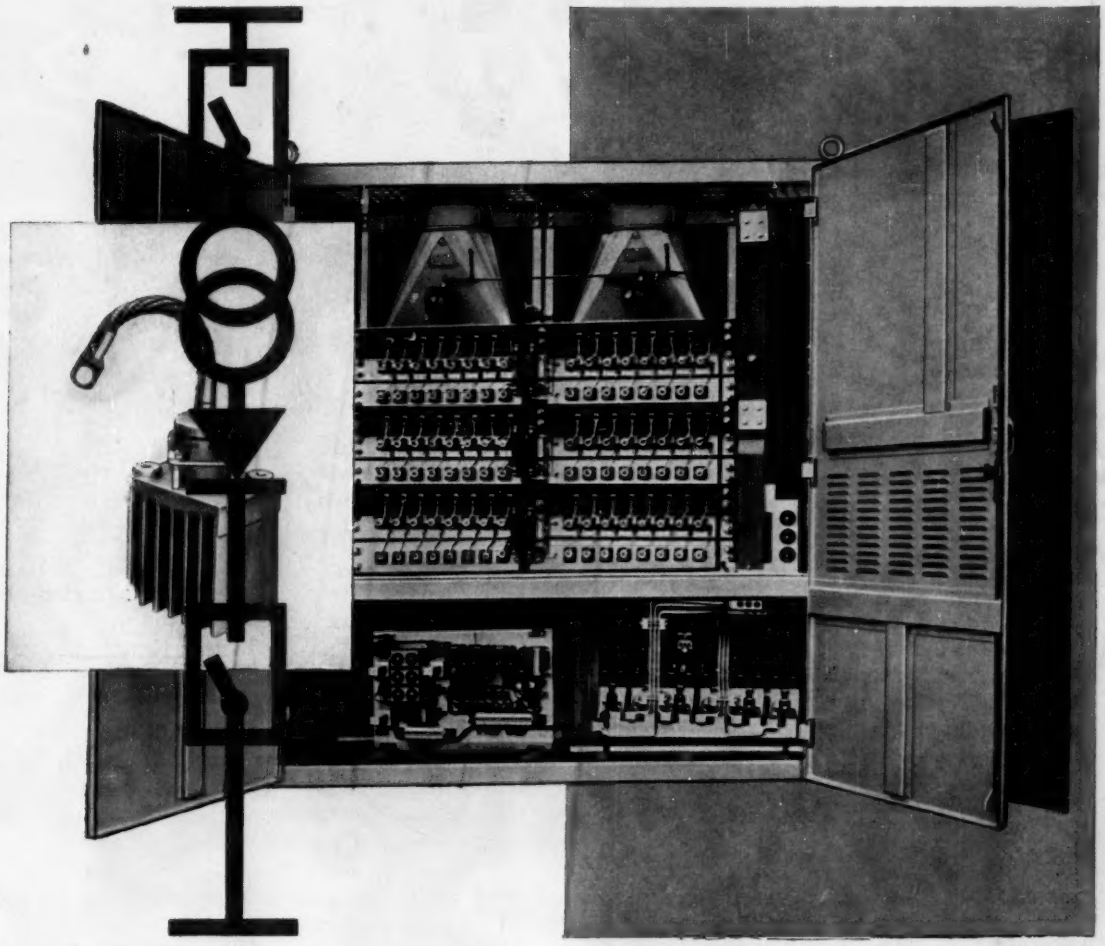
For full information on "WHITE" and "BLACK," see your J-M Distributor . . . or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ont.

JOHNS-MANVILLE JM

AEG

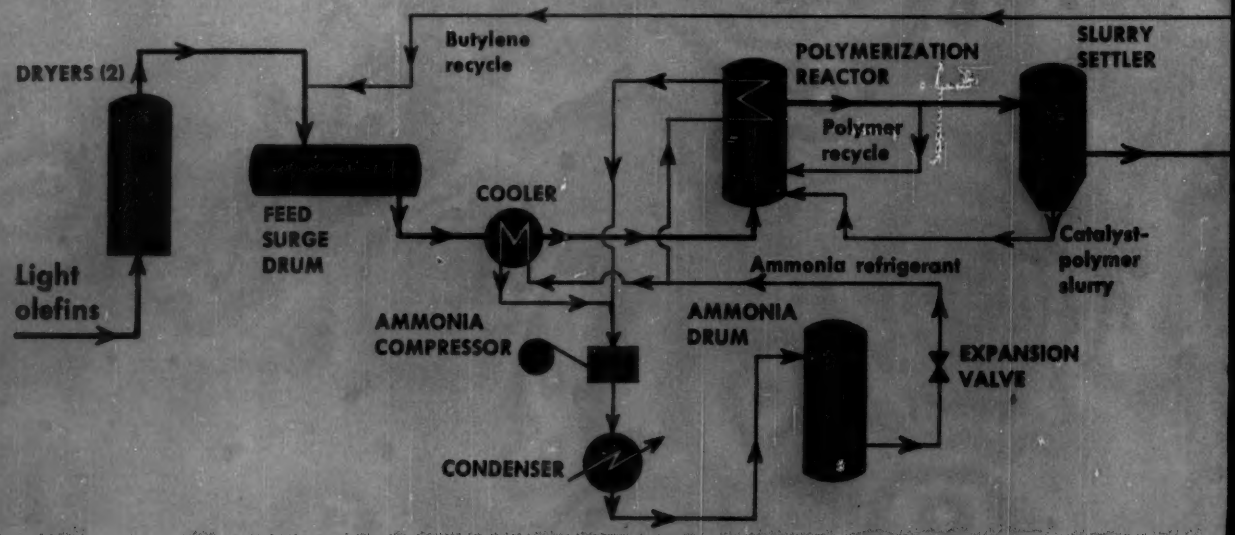
Germanium and Silicon Rectifiers

Of quality design and sturdy construction they ensure utmost efficiency and stable operation under all conditions of service.
Let us assist in solving your D. C. power problems.



9496a

ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT
EXPORT DEPARTMENT
Berlin (West)
Frankfurt (Main)



Polybutene Process Ready for Export

Efficient process that Cosden Petroleum developed and currently uses in a modern Texas unit will soon produce Europe's first output of polybutene at a French plant.

A process developed by a moderately sized inland-Texas oil company will soon be turning out Europe's first production of liquid polybutene.

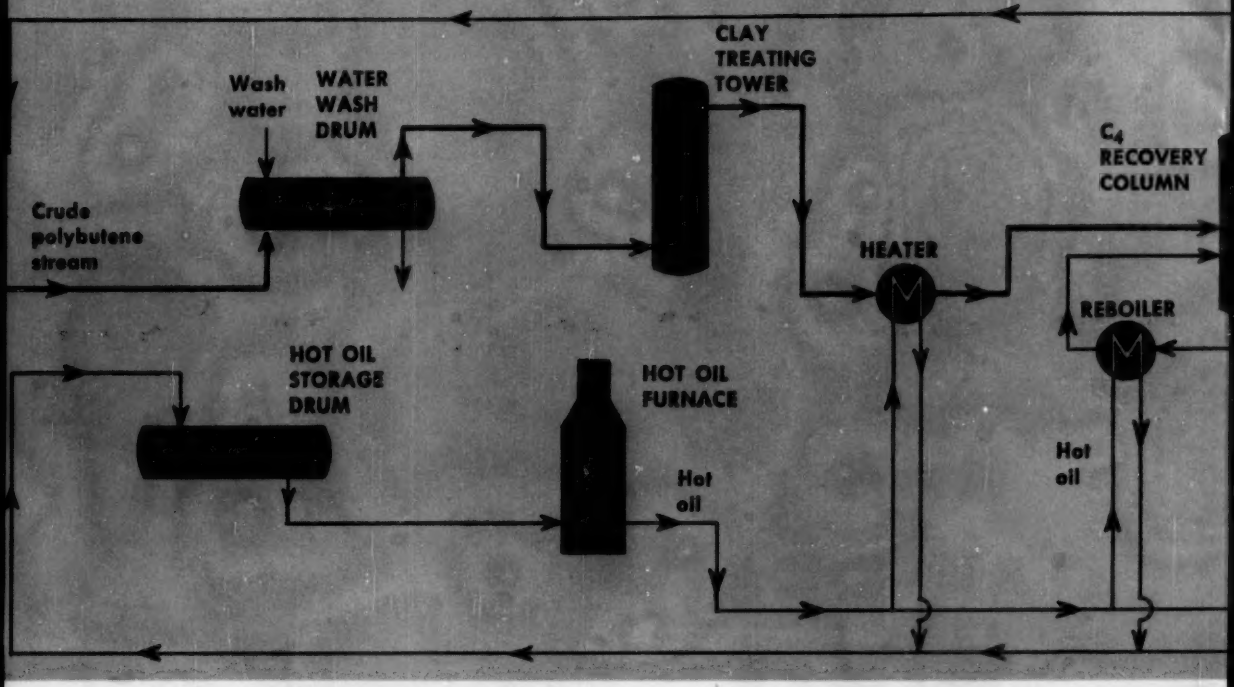
Owner of the process is Cosden Petroleum Corp., of Big Spring, Tex. Cosden's European licensee will be Naphtachimie, an organization formed jointly by Pechiney of France and Societe Francaise des Petroles BP about 10 years ago, which will build its polybutene unit near Lavera in the south of France. Cosden is granting Naphtachimie an exclusive manufacturing license for the European Common Market, which includes France, Belgium, Italy, West Germany, Holland and Luxembourg.

Cosden's process is represented today by a 7,000-gal./day plant which the company operates at its Big Spring refinery. The plant treats C_4 olefin feedstock furnished by thermal and catalytic cracking units, produces a wide range of polybutenes which Cosden markets under the Polyvis trademark.

▶ **What's in a Name**—Polymerized butene products are known both as polybutenes and polyisobutylenes. Generally, the latter name refers to solid, rubberlike products having a high molecular weight. On the other hand, polybutenes—the class of products made by Cosden—are viscous, tacky liquids. Cosden produces them in a molecular weight range of about 700 to 1,500.

Polybutenes are chemically inert and they exhibit good resistance to heat and aging, as well as desirable electrical properties such as high dielectric strength and resistivity. Their viscosity and tackiness depend on molecular weight; values for both properties become higher as the molecular weight increases.

Unfold Flowsheet



These materials are used in various applications. One big area is adhesives—an example is cellophane tape. In addition to their adhesive uses, the materials improve viscosity properties of lubricating oils when blended as an additive, contribute flexibility to resin formulations when used as plasticizers. Other applications for polybutenes include manufacture of caulking and sealing compounds, electrical insulation and protective coatings.

▶ **Industry Picture**—Cosden is the smallest of the petroleum companies that produce polybutene.

Oth
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Refi
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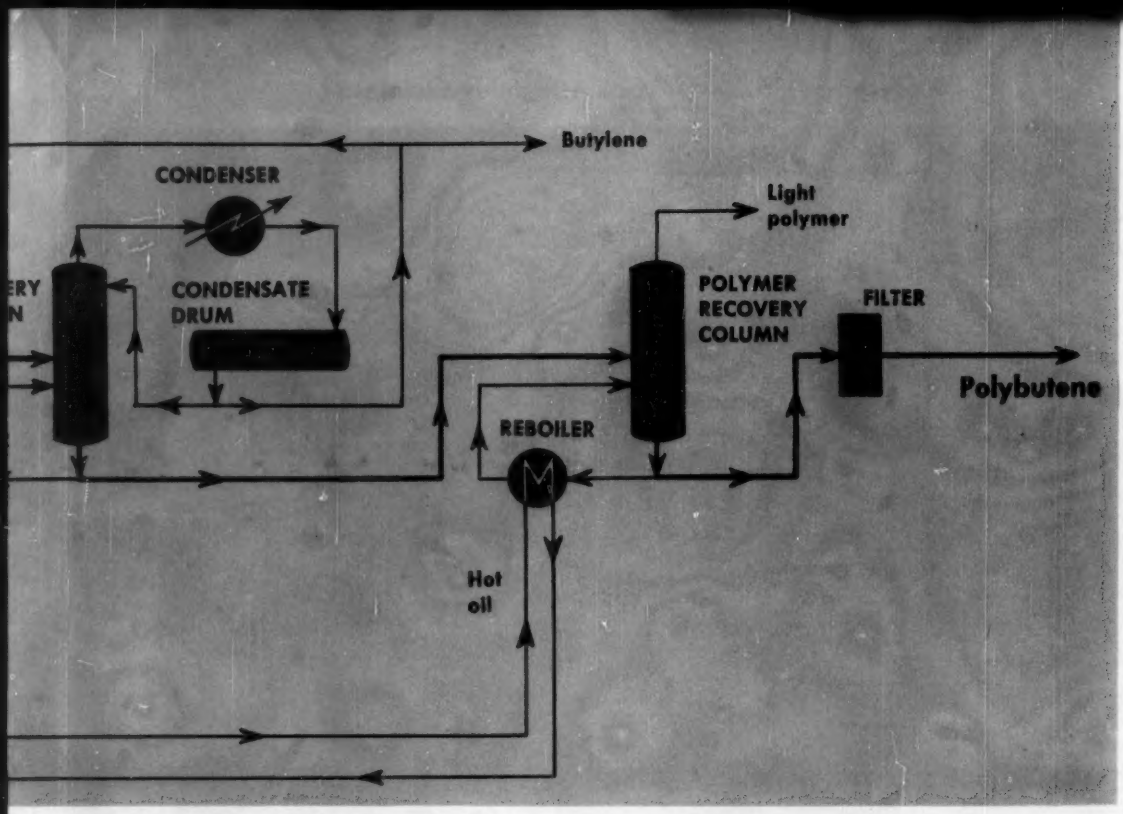
in t

FIRST the feed passes through one of the dryers shown on the right. Furnace, rear, is part of hot oil system.

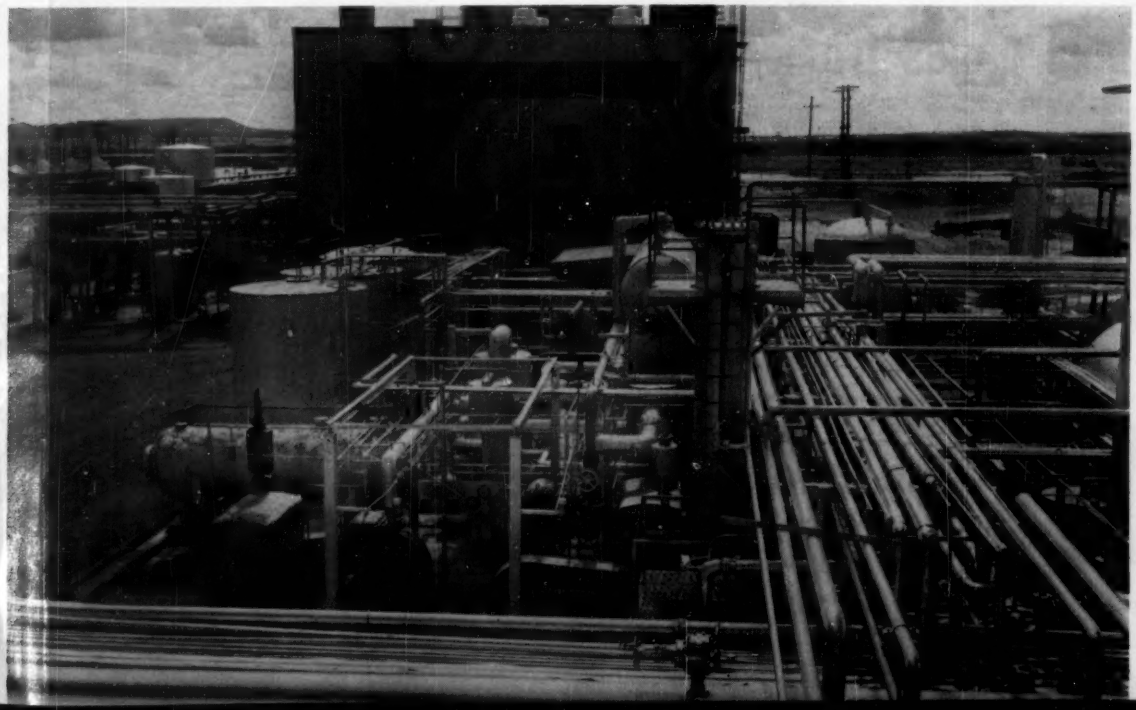
THE



Others in the field include Oronite (a subsidiary of Standard Oil of California), and Standard Oil Co. (Ind.). Enjay Chemical Co. (Humble Oil & Refining's petrochemical marketing division) also offers a polymerized butene, but its product falls in the solid, polyisobutylene category.

First in the field was Standard Oil of California, which pioneered production of polybutene about 20 years ago. Stancal's Oronite operation is currently planning a substantial expansion which will reportedly make the firm the largest polybutene producer in the world.

THEN the feed enters the reactor section of the unit, which includes a refrigeration system to remove heat of reaction.



FINAL

Cosden has been in the commercial polybutene business since 1956, although its experience with the polymer dates back to 1953 when the company started an experimental operation which produced small batches for development purposes. Company expanded and modernized its Big Spring unit last year.

▶ **Features**—A principal strong point of Cosden's operation is its flexibility as regards feedstock. The plant receives a C_4-rich olefin feed from cracking units, can process this stream directly without requiring expensive preconcentration of isobutylene.

Cosden furnishes process heat for the plant by a closed system which circulates hot oil. The oil flows from a storage drum through a furnace, then through the plant's heaters and reboilers and back to the drum.

▶ **The Process**—Cosden starts by passing its feed through one of two percolation-type dryers which use bauxite as drying medium. The dryers are sized so that they can operate for 12 hr. before requiring regeneration.

Dried stream flows to a feed surge drum, where it combines with butylene which is recycled from product purification towers downstream.

▶ **Polymerize**—The combined feed goes through a cooler, then enters the polymerization reactor. Catalyst is anhydrous aluminum chloride that is activated by gaseous HCl.

Reaction which forms the polymer is exothermic, and Cosden removes heat by using an ammonia refrigeration system. Reaction temperature must be carefully controlled because it governs the molecular weight of the polymer produced. The reactor is designed for a temperature range of 70 F. to −20 F.

▶ **Settle Slurry**—Reactor product is led to a settler, where the catalyst settles out as a slurry with some of the polymer. This slurry is withdrawn and piped back to the reactor.

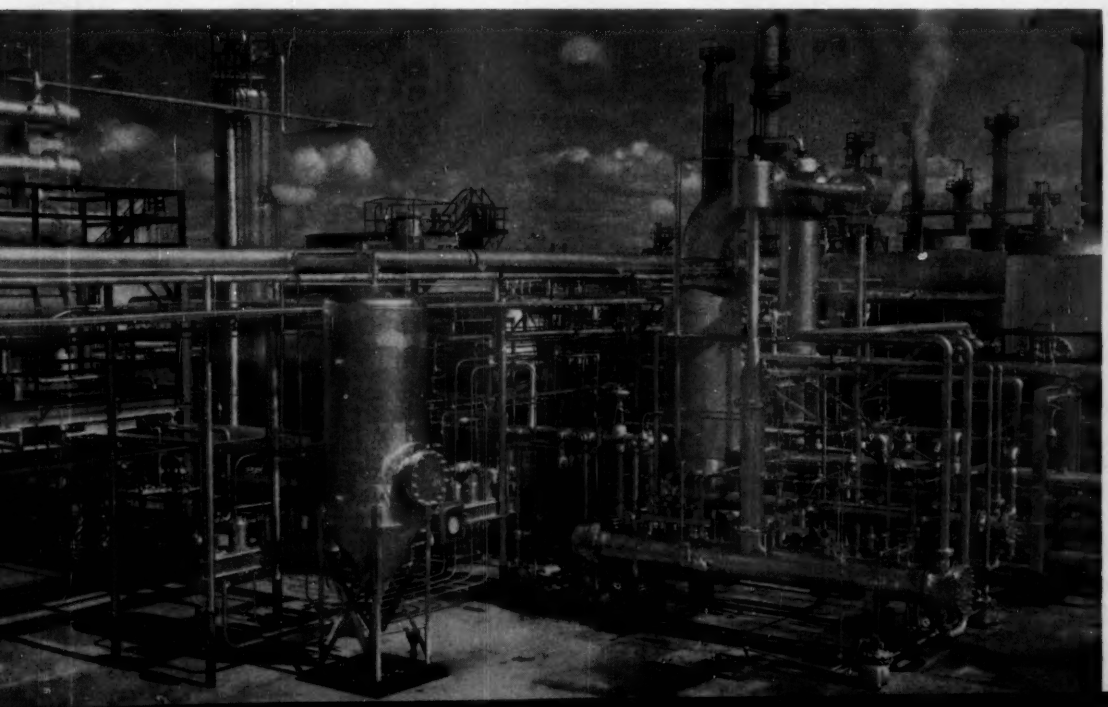
Product mixture goes from the upper part of the settler to a water wash drum, which removes residual aluminum chloride and HCl. Next it passes through a clay tower containing bauxite which further cleans the stream by removing color bodies.

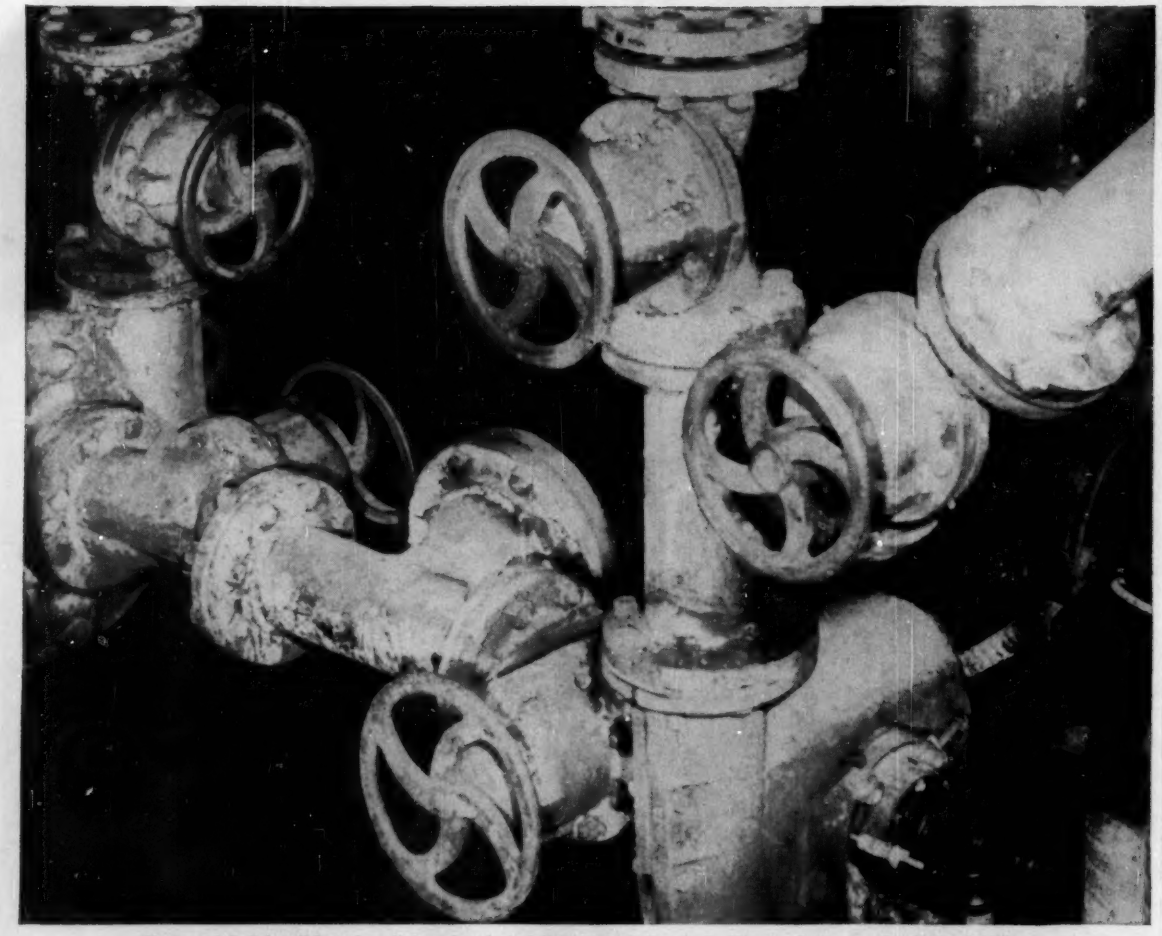
▶ **Finish Purification**—Next step is to recover the unreacted C_4's. Product stream from the clay tower passes through a heater and into a conventional distillation column, where the C_4's are withdrawn as overhead product. Part of the overhead stream recycles to the feed surge drum. The rest leaves the plant, goes to other refinery processing units.

Bottoms from the column are fed to a vacuum tower which removes any light polymer formed in the reactor. Vacuum is furnished by a multistage jet system; this system includes interstage surface condensers where the light polymer is recovered. After recovery, the material is recycled to Cosden's thermal crackers for recracking.

Final purification of the polybutene stream takes place in cartilage-type glass filters which remove any residual solids. A continuous viscometer measures and records the viscosity of the finished polymer.

INALLY the polymerized material is purified in towers where unreacted olefins and light polymer are removed.





Cluster of 5 Grinnell-Saunders Valves in electrolytic plant of the S. D. Warren Company, Cumberland Mills, Maine, where chlorine solution is made. The 5" rubber-lined Grinnell valves with rubber diaphragms are on lines going from storage tanks to hardwood bleach. Valves here have been in use 9 years with very little service required.

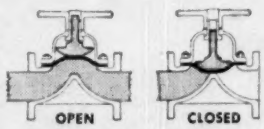
In use on chlorine lines 9 years with practically no maintenance!

It's the design of the Grinnell-Saunders Diaphragm Valve, plus selection of the correct body and diaphragm materials, which make it long-lasting.

The product in process is isolated from the valve's working mechanism at all times, so there can't possibly be any corrosion from that source. No product contamination can occur through contact with the operating mechanism, because the diaphragm effectively "seals off" the fluid in the line. The only part of the valve normally subject to wear is the diaphragm — which can easily be replaced without removing the valve from the line.

You can have Grinnell-Saunders Diaphragm Valves in a wide choice of body, lining and diaphragm materials. For further facts about Grinnell-Saunders Diaphragm Valves, see Grinnell's insert in Chemical Engineering Catalog, or Sweet's Plant Engineering File — or write directly to Grinnell Company, Providence 1, Rhode Island.

In the "open" position, the diaphragm lifts high for streamline flow in either direction.



In the "closed" position, the resilient diaphragm seals tightly, even over fibrous particles and grit.

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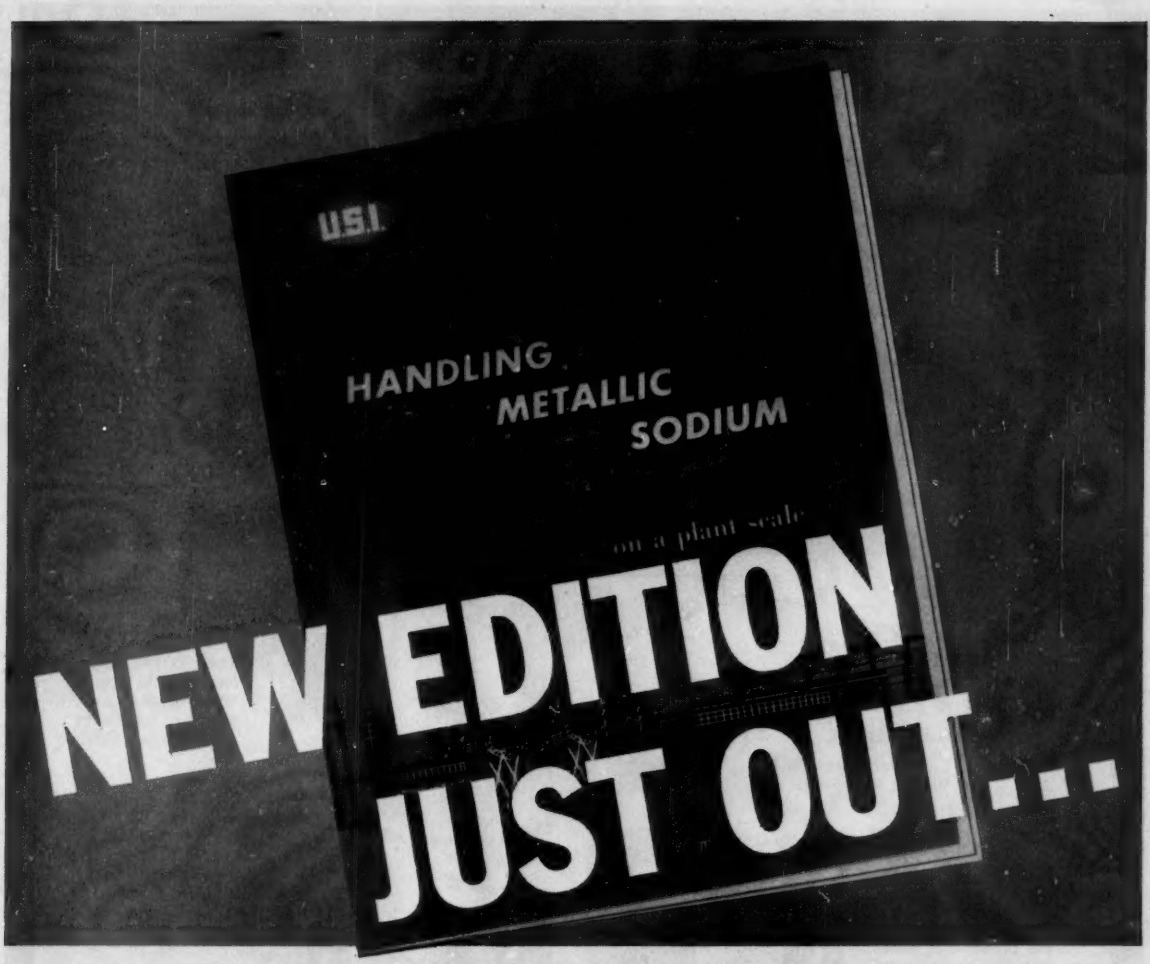

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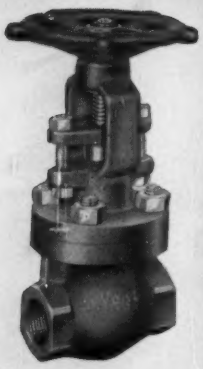

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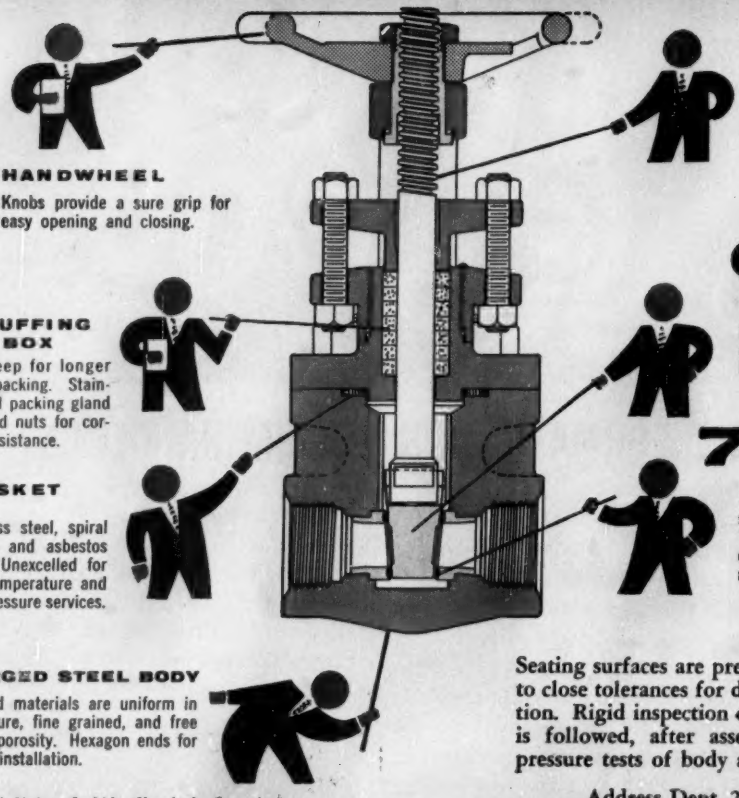

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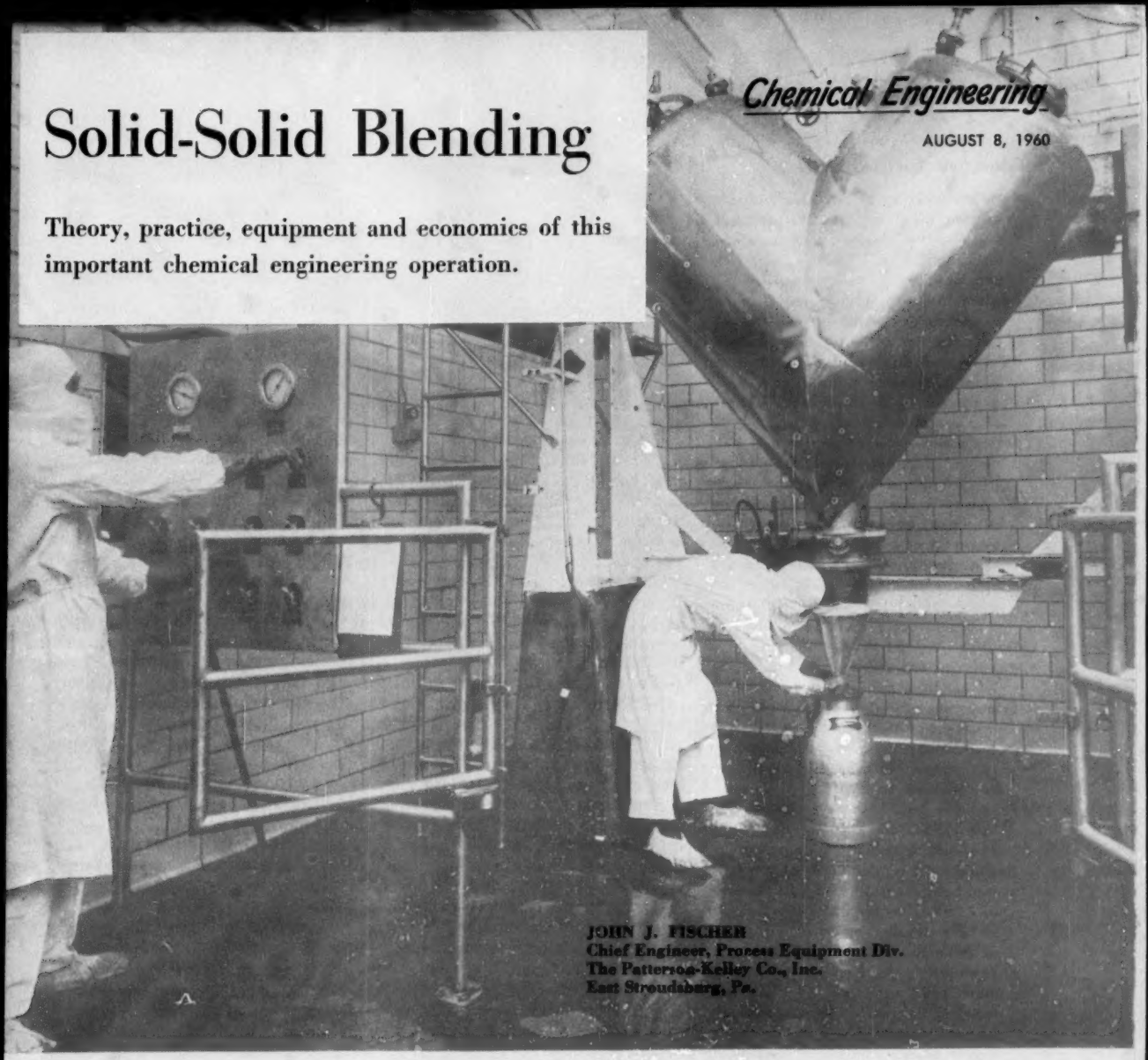
Chemical Engineering
AUGUST 8, 1960

Solid-Solid Blending

Theory, practice, equipment and economics of this important chemical engineering operation.



JOHN J. FISCHER
Chief Engineer, Process Equipment Div.
The Patterson-Kelley Co., Inc.
East Stroudsburg, Pa.

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OF ALL the millions of words that have been used to discuss chemical engineering operations, expressions mouthed by men on the job are difficult to surpass for sheer vividness.

"Like picking fly specks out of pepper with boxing gloves on," is a well-known classic.

This report covers a chemical engineering operation that is analogous to spreading those specks throughout the pepper in the first place.

Blending solid particles is a complex engineering art. With effort, it may become an engineering science some day. Perfecting it into an economical, precise operation in spite of the "boxing gloves" has been your author's main concern for the past 15 years.

For orientation (see *Chem. Eng.*, Aug. 1956, p. 175), blending is one of several important solid-solid contacting operations. This report excludes those processes wherein the addition of a small amount of liquid reduces electrostatic charge, aids blending or catalyzes chemical reaction.

Glossary for Solids

Aeration—Mixing of particles with air so that they tend to float without touching one another, and therefore tend to flow very freely. See "Suspension."

Agglomerate—To gather into clusters. As noun: A cluster or granule of particles that adhere to one another.

Batch processing—Handling or processing a quantity of material at a time, in contrast with treating it as part of a continuous flow.

Bulk density—Weight per unit of volume of a quantity of solid particles. Usually expressed in lb./cu. ft. Bulk density is not a constant. It can be decreased by aeration, increased by vibration or mechanical packing.

Critical quantity—The smallest amount of a blended material in which accuracy of mixing will be significant during use or further processing.

Density—Weight per unit volume of a particle expressed in grams/cc. or lb./cu. ft.

Electrostatic charge—Unbalanced distribution of electrons on particle surfaces that influences their attraction to or repulsion from other particles, or container surfaces.

Flow—The fluid-like movement of particles that occurs when they move past one another.

Granule—An agglomerate of particles that behaves itself as a particle. Usually formed by blending with a liquid or with smaller particles that serve as adhesive agents.

Key material—In a blend of two or more solid materials, the key material is the one constituent (usually present in a relatively small proportion) whose uniform dispersion throughout the blend is most important to the success of the operation.

Key particles—Particles of the key material in the blend.

Masterbatch—A blend of all the minor ingredients that go into the bulk components.

Overblending—Inducing electrostatic charges by excessive mechanical work on particles in a blender. See "Unblending."

Perfect blending—Arranging particles in a mixture so that individual particles of each kind are distributed with exactly uniform spacing among all the other particles. See "Random distribution."

Premix—A blend of the key ingredient with a portion of another material, prepared in anticipation of further stage blending with more of the other material. See "Masterbatch."

Random distribution—Arrangement of particles in a mixture so that the probability of a single particle being at any one location is just as great as the likelihood of it being at another location.

Random motion—Movement of particles past one another in a mixture by force of gravity, mechanical pushing or a combination of both.

Sample—Usually not a single quantity of material, but a number of spot samples taken from a batch at the same time.

Segregation—Separation of mixed constitutents during handling, transportation, blending or processing.

Solid particle—A piece of material—usually small—that has a shape and a size which remain relatively unchanged in the absence of physical or chemical action.

Specific gravity—Weight per unit volume of a particle expressed as a ratio to the density of water.

Stage blending—Blending a key ingredient with a portion of another ingredient; then introducing this blend into more of the other ingredient progressively by blending stages.

Standard deviation—Statistical measure of how much the concentration of one constituent in a sample varies from the true concentration that characterizes the entire blend. Is mathematically proportional to the error.

Suspension—A free-flowing, fluid-like mixture of solid particles in a fluid. Usually air is the fluid for blending operations. See "Aeration."

Unblending—Segregation of constituents that have been partially or completely mixed. Usually caused by accumulated electrostatic charges.

1—Why Blend Solids?

To make more valuable solid mixtures from less valuable raw materials. To control process variations.

Blending operations have always played an important part in the household arts, domestic sciences and in industry. Several recent trends are directing more attention to blending as a commercial chemical operation.

One is the increasing popularity of factory-prepared household products. This trend is taking more operations out of the home and into the plant.

We can buy sand-cement mixtures for mortar, and chemical mixtures for fertilizer. Our kitchen shelves are full of ready-to-cook or ready-to-serve mixtures. Our medicine cabinets store pharmaceutical preparations that feature combinations of ingredients. All involve blending so that we need not purchase the materials separately and mix them ourselves.

Of far more commercial importance than the "convenience" blends, however, are the many plant operations in which dry materials must be combined as part of the manufacturing process. The tremendous growth of the chemical process industries has stimulated this need to a point where dry solids blending has become a well-recognized—if not well-understood—plant operation.

Such products as plastics, pigment dispersions, adhesives, antibiotics, cosmetics, ceramics, welding fluxes, corrosion inhibitors, sintered metals, insecticides, glass, dry-cell electrolytes and wallboard all entail some sort of blending operation.

Situations in which blending is indicated fall into a variety of categories:

Control of variations that occur in a single material can frequently be perfected by blending. Plant processes, no matter how carefully controlled, sometimes turn out nonuniform or off-standard materials.

When it is difficult or impossible to control the composition of a product within critical limits during its manufacture, blending can provide an answer to the problem.

A number of batches that are off-specification in some respect may be blended to achieve a uniformly satisfactory product.

Pharmaceutical compounds that are difficult to produce without a certain amount of variation from batch to batch have been blended to provide a "bank" of uniform material made up from a number of batches.

Mixtures are required for many chemical process inputs, and they are produced by blending the constituents. Often a mixture is marketed as a standard product to end-users or to other processors.

Fillers or extenders must be added to certain materials because in their pure form they are too potent for effective use or safe, convenient handling. Medicinal products such as antibiotics are an example. So are certain explosives, pesticides and reactive chemicals.

Sintered metals are handled first as particles. They may be blended with other metals, with temporary binders to aid the molding process or with void-producing materials that escape during the actual sintering operation.

Foods, flavoring and spices require blending in many pre-packaged mixes. So do such additives as preservatives and stabilizers.

Pigmentation almost always entails a blending and dispersing operation to transform a pigment powder and a vehicle into a usable product. The vehicle may eventually take the form of a paint, lacquer or ink. It can be a paste or a masterbatch suitable for further blending, dispersing or processing.

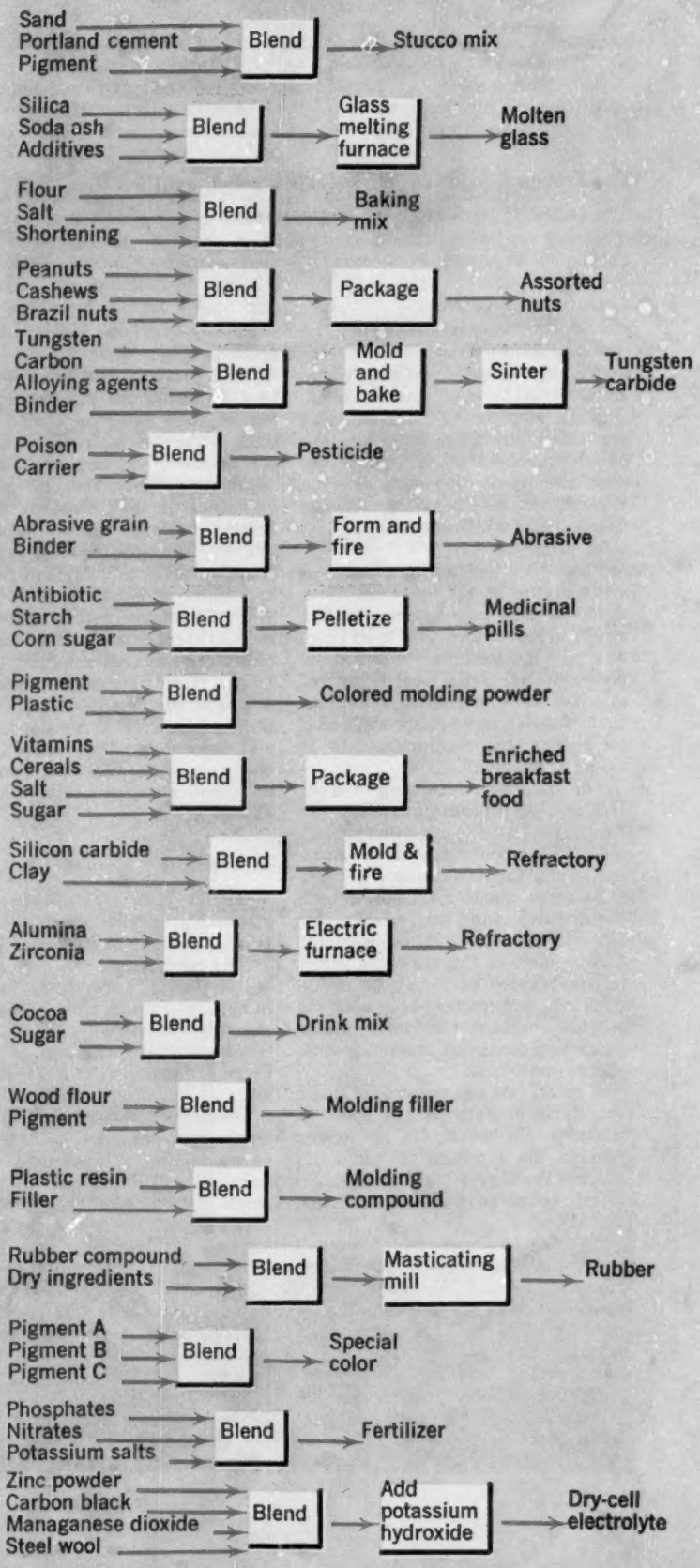
The impressive expansion that the use of plastics has enjoyed has brought many applications of blending for dispersing the pigments on plastic resin pellets or powders.

Colored ceramic ware and colored glass require a blending of solids before the firing or melting stages of manufacture.

Almost every industry depends in some important way on a blending operation at some stage of manufacture. As the tabulation at the right demonstrates, this is very often a solid-solid blending operation.

Typical Dry-Blending Operations

Minor ingredients omitted for sake of simplicity



2—What Is a Solid?

The frozen liquid, which we call a solid, exhibits drastically limited capacity to change its shape or size.

Any fundamental discussion of blending solid particles must necessarily be predicated on some prior understandings and qualifications.

First step is to sum up and organize many basic facts and experimental observations. Only from such an orderly approach can the ancient art of blending emerge as a scientifically understood industrial process.

Thus, it's appropriate to consider at the outset what the term "solid particle" actually means. One might presume that this is so obvious as to need no elaboration. Nevertheless, the behavior of minute solid particles resembles that of fluids in so many ways that to neglect the distinctions is to invite confusion.

The familiar phenomena of melting and vaporization, which are reversible in the case of many materials, provide convenient starting points for describing a solid.

As a gas, a material changes both its size and shape very readily. Its size—the volume it occupies—is independent of the crowding effect of other gases that may be mixed with it. Mixtures are easy to achieve because thermal effects promote a continual random motion of gas molecules.

A liquid can also change its shape readily to conform to the space it occupies. However, it no longer retains the freedom to adapt its volume readily to "fill" that space. Mixtures can be produced by simple agitation.

The frozen liquid, which we call a solid, exhibits drastically limited capacity to achieve changes of shape or size if we examine it particle by particle. Each piece of material has its own shape, and it has a size.

Of course, size changes can be accomplished by breaking solid particles apart to make smaller ones. Also, particles can be joined together by various mechanisms to produce larger ones.

Solid particles can be suspended in a fluid and the suspension may behave very much as a fluid does. Also, solid particles can roll over one another, and they may almost duplicate some of the flow properties that liquids display in this respect. Under the influence of gravity, however, flowing particles come to rest at an "angle of repose" and not at a "liquid level."

These differences and near-similarities emphasize the fact that the only clear way to distinguish a solid from a liquid or a gas is to consider a single, discrete particle. If that piece of material is a solid, it has a size and shape that remain relatively constant unless some physical or chemical action takes place to change them.

A Dynamic Constancy

Relative constancy of shape and size can thus be adopted as a practical working test characteristic of a solid particle.

But there are very few situations in nature in which this constancy is absolute. Changes always occur. Some of these changes, such as thermal expansion and contraction, are significant in large masses—in a concrete highway slab, for example. Others, such as adsorption or absorption of moisture tend to have more pronounced effects on small particles with their huge ratios of surface to volume.

The natural phenomena that affect small solid particles most significantly can be enumerated and some of the effects described.

Mechanical force can break a particle. It is possible to shatter it, in some cases, to produce a multitude of smaller particles.

More often, mechanical forces are exerted in such a way that the action is abrasive or erosive. Minute bits of material—small in relation to the particle itself—are separated from the surface. How rapidly this occurs—and whether it occurs—will depend on the shape of the particle involved, its resiliency, its brittleness and on the severity of mechanical forces exerted on it.

Sometimes, mechanical forces tend to weld small particles together to form larger ones. Surfaces are forced together sufficiently intimately to bring molecular adhesive forces into play to a certain degree. This can occur in the absence of another material to serve as a bonding agent, and at higher temperatures it may involve a certain amount of plastic flow.

Temperature influences the manner in which a particle reacts to mechanical forces, and has several other effects besides.

The tendency of some materials to bond together and agglomerate at higher temperatures has been mentioned. Some thermoplastics and plastic-like compounds tend to soften and to present viscous liquid surfaces as temperature goes up. This occurs even though each particle is still in a state where it can be called a solid.

At low temperatures certain materials become more brittle. This tends to increase their susceptibility to fragmentation and erosion.

Elevated temperatures — especially when combined with low absolute pressures—will tend to accelerate the release of volatile material from the surface of a solid particle. Effects of evaporation of the material itself or release of absorbed constituents are not usually significant in the case of larger solid bodies. But minute particles with thousands of millions of times more surface area per unit mass call for a different conceptual approach to such phenomena.

Absorption or adsorption of any fluids that may be present in a particle's environment can create several kinds of changes without destroying the particle's identity as a piece of solid matter.

Density may be increased or decreased. Conditions that promote or inhibit chemical reaction may be set up.

Surfaces of the particle may be coated. Usually, this promotes adherence to adjacent particles and agglomeration. However, depending on the nature of the coating, the effect may be quite the opposite.

An adsorbed coating sometimes insulates and lubricates each particle so that it will not adhere to its neighbors.

Large Electrostatic Effects

Electrostatic effects that are completely obscured in the case of large masses exert a profound influence on the behavior of small particles. This, again, is a direct consequence of the relatively enormous surface areas present compared to the mass of the material.

It's possible to draw a sharp line between the electrostatic phenomena observed when particles are attracted or repelled by charges and the fundamental molecular attractions that make solids behave as solids. Matter itself is held together by the attractions and repulsions associated with electron deficiencies and excesses.

In the case of extremely small particles the same deficiencies and excesses occur at localized areas. However, there is a vast difference in energy levels. Compared with the attractions between atoms that bond them into chemical compounds, the attractions between adhering particles are very small.

Actually these forces have not been measured in any laboratory experiment known to the author. Their existence is deduced from observation of how different kinds of particles behave during several kinds of carefully controlled laboratory procedures. Particles so small that they float freely in air will respond to forces so minute that their behavior—not the forces impelling that behavior—becomes the observable phenomenon.

Powdered plastic materials, for example, that flow freely in an uncharged state can be given an electrostatic charge by agitation or mechanical stirring. This mechanical work upsets the neutral balance of electron states on particle surfaces. Immediately, the mass of material changes its nature and ceases to flow freely. Particles adhere to one another, and they form agglomerates.

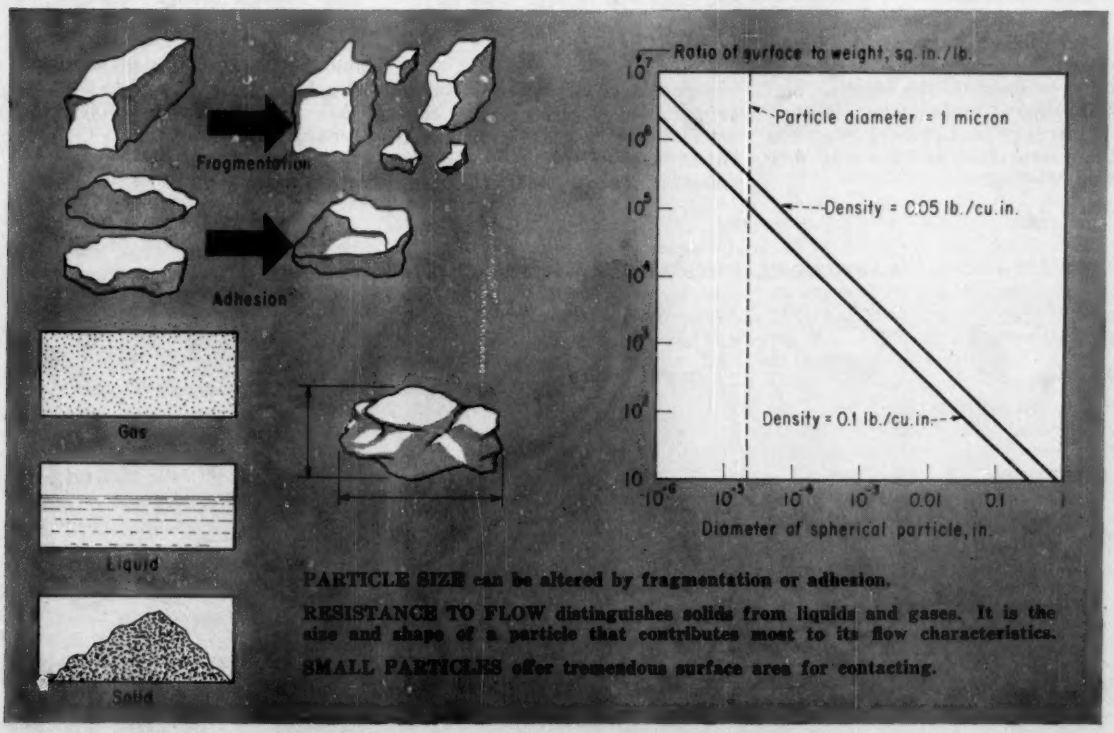
With time, in the absence of further work, the attracting forces that hold the agglomerates together tend to relax somewhat. Any factor that promotes electron flow, such as high humidity, will speed up the relaxation of attracting forces.

If particles of two different materials have accumulated mutually repellent charges, this can produce a situation where segregation forces are remarkably powerful. It may make it virtually impossible to mix the particles by mechanical means.

Chemical reaction can affect relatively large solid bodies in the presence of other solids, liquids or gases.

The same reactions will obviously proceed far more rapidly when small particles are involved. A large ratio of available surface in proportion to mass provides more potential reaction sites.

A discussion of chemical reactions of solids is beyond the scope of this report. We intend to cover the subject in a future article which will discuss the problems of blending solids in the presence of a liquid phase.


Fragmentation
Adhesion
Gas
Liquid
Solid
Ratio of surface to weight, sq. in./lb.
Particle diameter = 1 micron
Density = 0.05 lb./cu.in.
Density = 0.1 lb./cu.in.
Diameter of spherical particle, in.
PARTICLE SIZE can be altered by fragmentation or adhesion.
RESISTANCE TO FLOW distinguishes solids from liquids and gases. It is the size and shape of a particle that contributes most to its flow characteristics.
SMALL PARTICLES offer tremendous surface area for contacting.

3—How Different Kinds of Solids Behave

Particle shape affects flow characteristics. Do you have rods? Filaments? Flakes? Blocks? Crystals? Chips? Pellets?

It's difficult to name any solid material in nature that cannot exist in small particles. Immediate qualifications to this generality suggest themselves, of course.

Some solids, such as wood and concrete, are not homogeneous. When broken down into dust-size particles they become mixtures of a number of different chemical materials.

Other materials are difficult to maintain in the particle state. Ice is a common example. Snow crystals can be considered to be ice particles. Their tendency to agglomerate into snowflakes or to evaporate into vapor suggests that tiny ice particles would have to be treated under very carefully controlled conditions.

In some practical operations with commercial materials, it's necessary to take corresponding precautions to maintain the identity, size and shape of individual particles.

Shapes of particles are related to their structures and the way they were formed.

Crystals assume the characteristic shapes of their ordered molecular structure. This may be modified by mechanical erosions. Fragmentation products may resemble crystals or may be a highly random distribution of many shapes and sizes.

Nearly spherical particles are formed by certain manufacturing processes. Also, the larger particles in a mixture that has been subjected to mechanical erosion may tend to be spherical, though the fragments eroded from them may not be so smooth.

Other shapes that occur—especially among the fines in the particle size range normally considered "dust"—are flakes, rods, filaments and chips.

Significance of Shape

Significance of particle shape lies primarily in its effect on flow characteristics of a mass of particles. Other factors being equal, the smooth-surfaced, spherical or egg-shaped particles tend to flow readily. The rough-hewn fractured pieces are less mobile. At the other extreme, the interlocking filaments, rods and complex crystals often flow so poorly that they tend to set up a small-scale equivalent of a log jam.

Another point regarding shape is that the irregular configurations display more surface area, size-for-size, than the spherical shapes. This can be of importance as it affects such things as chemical reaction or absorptivity. It can also enhance mobility when an aerated suspension is created during blending or handling.

Wide Size Range

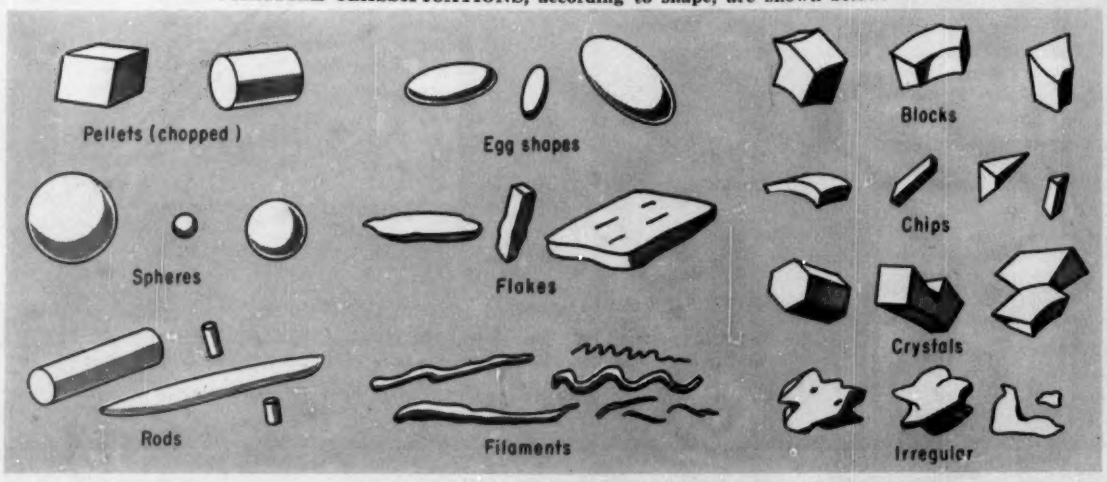
Sizes of particles considered here range from those approximately 1 micron in principal dimension up to such relatively large pieces as plastic pellets, seeds and nuts.

More important than the nominal or mean particle size is range of sizes in a batch or group. Particle size distribution can influence the behavior of a group of particles most profoundly.

Large and small particles tend to segregate themselves whenever they undergo mechanical agitation or movement of any sort. In a flowing situation, the larger pieces roll the farthest. In an agitating situation, the fines tend to dust out while the coarse particles settle by gravity.

In a mixture of fines and larger particles with irregular shapes, the

PARTICLE CLASSIFICATIONS, according to shape, are shown below.



fines themselves are sometimes able to support the coarse ones in blending.

Density of particles can be high or low. Of itself, density has little significance. However, if particles of radically different densities are handled together, they may tend to segregate themselves in very much the same manner as particles with a wide spread in size distribution. The heavy ones go downward and the light ones rise. This effect can be countered by keeping particle size uniform and small.

The important factor is the ratio of the supporting surface to the mass.

Chemical composition of a particle has little or no effect on its behavior as a particle, provided it is stable and unreactive in its environment. If it changes form in a chemical reaction, then all the other factors mentioned here may come into play.

Surface Effect Important

Surface conductivity of a particle, its tendency to hold a static charge or to dissipate electron imbalances readily, is a property that has a profound bearing on how it behaves with other particles of the same or different composition.

This property can be modified in various ways. Also, the charge-holding tendency of a particle can be countered by handling it in such a manner that it accumulates little or no charge during its processing cycle.

Generally, the good insulators—plastics and other organic compounds—tend to be charge accumulators. Metal powders and salt granules display less of this tendency under comparable conditions. However, the nature of the particles and particle mixtures is such that complete electrostatic neutrality is seldom achieved in practice. Even minute charges can influence the mobile behavior of the very small masses involved. Therefore, this variable always remains as a potential problem to be combated.

Ease of Flow: Lubricity

Lubricity of particles cannot be defined in precise terms. It is true that some types of particles will flow more readily than others under the same conditions even though their shapes, densities and apparent surface smoothnesses may be nearly equal. This quality of flowability in a mass of solid particles corresponds roughly to viscosity of a fluid.

Some materials have so much lubricity, flow so readily, that any agglomerates in the particle mix cannot be supported at all. It then becomes very difficult to touch the agglomerates mechanically, because they find their way rapidly to the bottom of the container, eluding contact with most types of mechanical devices designed to break them up.

Materials that do not display the quality of lubricity can be made to flow. A degree of compensation exists in that these irregularly shaped fine particles are often very susceptible to aeration and suspension. In that state, they become readily mobile.

Differences in the nature of particles when two or more materials are present together can frequently have a major effect on how they behave.

The tendency of fines to dust out of an aerated suspension has been mentioned. When the two types of flow occur simultaneously (fluidized floating along with mechanical rolling) it may be necessary to adjust conditions to correlate them. It's usually possible to keep flow velocities in a range where just enough aeration is introduced to move the nonrolling particles but not so much as to separate them from the rest of the mix.

4—The Mechanism of Blending Solids

Random action is a tool that works. But you must consider the forces and mechanisms that work against random distribution.

Mixing or blending of materials is an age-old process. Any discussion of it has to describe everyday concepts that appear to be quite rudimentary. A very young child knows what is meant by "stir it up." Much of today's industrial practice in this area is no more sophisticated than that.

At the same time, there are facets of the mechanics involved, the theoretical concepts and the statistical analyses of results that challenge the most erudite investigator.

Random Action Helps

Random action is the tool that helps achieve a mixture. In gases, kinetic energy promotes mixing. Liquids are mixed by a similar phenomenon, and the process is usually speeded by agitation. For solids the process is analogous, but there are more factors working to inhibit free, random flow.

Blending equipment for solids falls into two general classes. One type pushes the material with blades or paddles. The other uses gravity to impel flow. Blades or baffles are often incorporated into gravity blenders to increase the complexity of the flow paths.

The theory is that when several groups of solid particles are moved at random in the presence of one another, inevitably it will become impossible to keep them segregated. They will tend to mix. When the blend is complete, each constituent type of particle will be uniformly distributed among the other types of particles.

On the face of it this theory usually works out fairly well in practice. Witness all the blends with which we are familiar in our daily lives: coffee beans, grass seed, succotash, biscuit mix, etc.

Closer Look Needed

Increasingly higher standards of excellence in blending, however, are

compelling us to take a closer look at the perfection of blends that can be achieved.

Such products as pharmaceuticals that contain only a fraction of a percent of active ingredient in a neutral carrier are produced by blending. Here it is vital that the blend be precise within acceptable safety tolerance limits. The same is true to a lesser degree in the case of insecticides that contain barely more than trace amounts of the active constituents.

General recognition is being accorded to the principle that random motion, unmodified by any other functional mechanism, can achieve a random distribution of particles. As in a lottery basket, the statistical probability that ticket No. 100 is at one location is just as great as the probability of being at some other location within the lottery basket.

But a random distribution is not the same thing as a perfect blend. It may be adequate for the purpose, and usually it is. Where perfect mixing is wanted, however, the only way to achieve it is to place each particle where it belongs by some piece-by-piece sorting and placement scheme.

The idea of achieving a random distribution by random motion is based on the assumption that no other impetus is applied to the particles. Such is rarely the case in practice. Almost always, other factors are at work. They may promote segregation or mixing. There may also be an agglomeration, a particle breakdown or a coating process going on at the same time. Any such functional mechanism tends to invalidate—or at least to modify—the random-motion blending theory.

Segregation Mechanisms

Segregation mechanisms that interfere with random motion of particles operate in combination. Industrial problems are usually solved by minimizing the more severe ones. For purposes of discussion, they may be considered separately, even though they are seldom encountered in such simple form.

Large and small particles of the same material tend to segregate when an attempt is made to blend them with random motion. Correspondingly, the same phenomenon tends to occur when large particles of one material must be blended uniformly with smaller particles of another material.

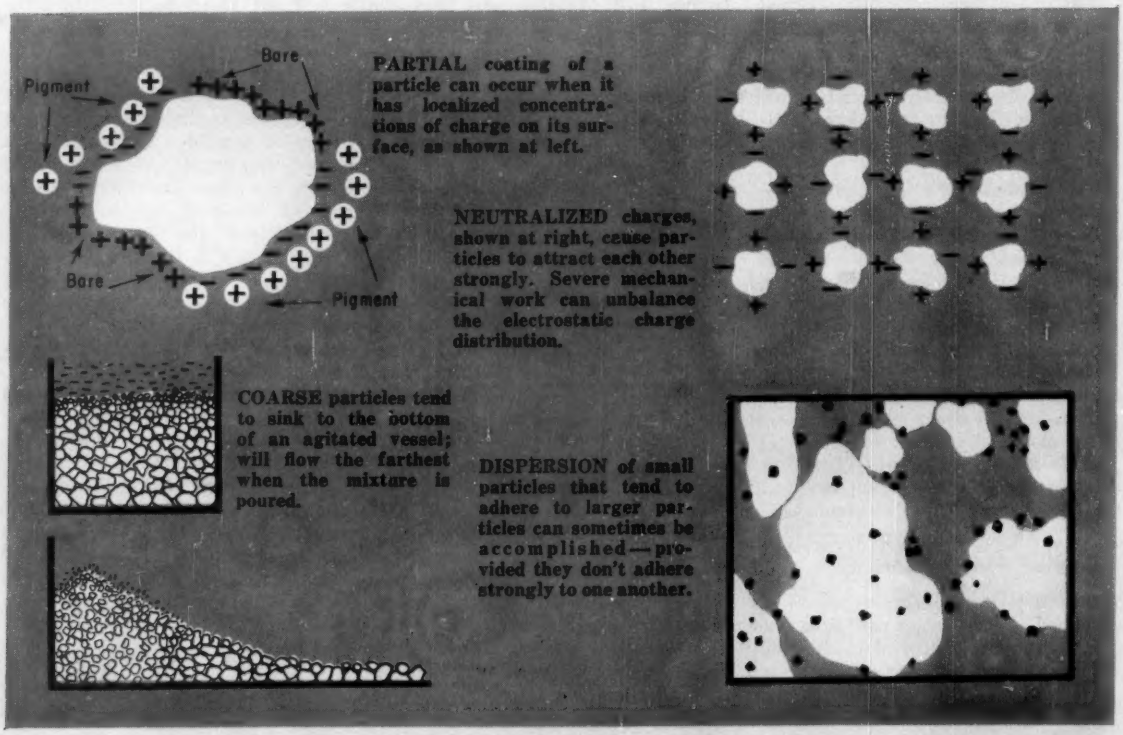
Because the larger particles gain their mobility by rolling and flowing over one another and the smaller particles achieve theirs more by aerated suspension, the fines often tend to dust out.

A theoretical remedy might be to blend in a vacuum so that no atmosphere would exist to support the fines. This has been explored to some extent, and it appears feasible for solving certain problems.

Most beneficial results in combating this form of segregation are usually gained by slowing down the random motion induced by the blender. Slow rotation of the vessel or blade treats the particle mass more gently. Dusting is minimized.

Another force that can come into play in this situation is a tendency of the small particles to coat the large ones. Again, the random distribution mechanism is upset. But this can be beneficial.

Achieving a good blend via coat-


Pigment
Bare
Bare
Pigment
PARTIAL coating of a particle can occur when it has localized concentrations of charge on its surface, as shown at left.
NEUTRALIZED charges, shown at right, cause particles to attract each other strongly. Severe mechanical work can unbalance the electrostatic charge distribution.
COARSE particles tend to sink to the bottom of an agitated vessel; will flow the farthest when the mixture is poured.
DISPERSION of small particles that tend to adhere to larger particles can sometimes be accomplished—provided they don't adhere strongly to one another.

ing is rare, because it depends on a happy proportion of ingredients.

The coated ingredient must be of uniform particle size or else the fines, with more surface/lb., will tend to grab more than their share of the coating.

Also, materials being blended must have a natural attraction for each other. However, in many cases, such an attraction can be enhanced by introducing into the mix an additive that will not deleteriously affect the process or end product.

Density differences among particles of essentially the same size tend to promote segregation. The heavy ones settle to the bottom of a mixture. This action is aggravated if the heavy particles are coarse and the light particles are the fines. Size differences and density differences can balance out, on the other hand, if the fines happen to be more dense than the coarse constituents.

While the range of particle densities may be something like 10 to 1, particle-size range may go to 100 to 1, or 1,000 to 1. Therefore, the ratio of particle surface to mass can be adjusted easily, if particle size can be controlled.

"Smeariness" of particles is a descriptive (though hardly scientific) term for a situation that can upset the pattern of random distribution in a blending operation. A characteristic of many types of finely divided pigments, this tendency of particles to adhere to one another makes them behave almost as a paste. The angle of repose of such a material may actually approach 90°.

Reasons for this behavior probably include static charge phenomena that promote tight packing and the extreme fineness of particles involved. They resist aeration which would make flow possible.

Often, the grinding, impinging action of other materials involved in the blending operation will serve to break up agglomerates of the smearing constituent. When this fails, it has been found by experiment that measures to modify the charge arrangement frequently yield success. Adding a surface-active agent can completely eliminate the smeary character of a material.

However, even this measure will prove unsuccessful in some cases.

Electrostatic charges on the surfaces of particles constitute the most powerful force—and perhaps the least recognized or understood—of all the mechanisms that work against random distribution of particles in solid-solid blending.

Much of the traditional lore of blending has been derived from experience with liquids, slurries and pastes. Electrical conductivity of such mixtures is relatively high, and so are the forces needed to introduce random motion.

In sharp contrast, solid particles in contact with each other—or more markedly when they are suspended as dust—exhibit far lower electrical conductivity on their surfaces. The forces that will cause such solid particles to move are extremely minute.

The relatively small electrostatic charges that can exist on solid particles, therefore, can produce drastic effects. They are the principal agent responsible for the phenomenon known as "unblending."

In a binary blend, for example, if all the *A* particles attract each other and repel all the *B* particles, it's possible to be confronted with almost perfect separation of *A*'s and *B*'s at the completion of the blending operation. Each end of the vessel will contain almost 100% *A* or *B* particles as the case may be.

This is an extreme example. While separation due to charges is not often so complete, its effects are encountered far more frequently than is generally recognized. It can prolong blending time, and it can be a factor in the production of unsatisfactory blends.

Another way in which electrostatic charges may manifest themselves is by setting up differences among the various faces of an individual particle. This can be detected by microscopic examination. It is not uncommon, for example, to see pigments adhering to certain faces of plastic pellets but refusing to coat adjacent faces.

The random motion that a blender imparts to its content particles, ironically enough, serves to make unblending possible. It does so in two ways:

1. Surface electron states are unbalanced by the frictional effects of particles as they rub against one another. Constant motion induces electrostatic charges.

2. This same motion gives the particles enough mobility so that they are freed to segregate themselves. Electrostatic forces alone may be too weak to cause motion on a large scale. But these forces are superimposed on random dynamic forces.

The combination, as static forces get stronger and stronger, becomes a more and more effective segregation mechanism.

To Prevent Unblending

Prevention of unblending may be approached by several routes. The simplest is to stop the blending cycle when the blend has been achieved.

Once a random distribution has been reached, no further benefit can be derived from further random motion of the particles. From this point on, if they are susceptible to unblending from electrostatic charge accumulation, further motion will only undo what has already been accomplished.

Radical segregation of the constituents into different regions of a blender will usually be prevented if they are introduced in alternate layers instead of completely separated. Then, once blending starts, it may go on to completion.

If material with static charges already imparted is interfering with proper blending it is sometimes possible to modify the prior operations to good advantage. The object is to attain the desired particle breakdown without doing so much mechanical work.

Some materials can be pulverized wet, then dried. Processes that dry particles in suspension instead of as a cake make it unnecessary to perform a second grinding operation on the solid cake. Where economic considerations permit, some change of this sort can be considered as a route to producing more blendable particles.

In those cases where the nature of the materials involved and the processes essential to their preparation combine to make the blending of charged particles unavoidable, another possible remedy is to introduce a surfactant into the mix. This approach has its advantages, but it's definitely not a cure-all. The wetting agent must contact each particle; must not create its own segregation problems.

Perhaps the most important step that can be taken toward combating segregation caused by electrostatic charges is to recognize the problem.

Then, every reasonable precaution can be taken to avoid subjecting the particles to unnecessary mechanical work.

Solids are blended mechanically. Particles in a blender are moved around so that they are free to come to rest near one another. This freedom of motion is essential to the blending process.

Usually, most success is achieved by doing everything possible to assure uniform mechanical mobility for all particles and the utmost freedom for each individual particle to flow at random.

5—What Characterizes a Satisfactory Blend?

In terms of quality, a good blend may not always be the most completely mixed or dispersed arrangement of particles.

The proof of the pudding is in the eating.

Actually, there is no more reliable or useful criterion for judging the quality of a solid-solid blend than an appraisal of the end product to which it makes a contribution.

In the same vein—provided the end product is satisfactory—one may investigate potential cost reductions that a better blend might make possible in the manufacture of that end product.

The glass industry provides an interesting example of economies derived from better blending. Ordinary glass with no special requirements as to quality can be produced by charging a glass-melting furnace with segregated or crudely mixed raw materials. However, far less furnace time and far lower fuel costs are possible when the same raw materials are charged as a good blend.

Here the important factor is not product quality but process economics. Physically, the explanation can probably be found in rapid achievement of a low-melting eutectoid composition. This avoids the necessity of fusing high-melting constituents completely. Mixing of the entire charge need not wait until they are molten.

Don't Make It Too Good

In terms of product quality, a good blend may not always be the most completely mixed or dispersed arrangement that the particles can be made to assume. Sometimes an intimate blend will be a waste, and it may even be undesirable.

For instance, piecrust mix should not have shortening too thoroughly blended with the flour. If it is, the crust of a baked pie will be tough. A certain amount of segregation makes for a laminated crust. This is ideal for eating, if not for structural reliability.

Another unusual situation in which complete or near-perfect blending is not as desirable as partial blending is in the operation where some kind of powder and binder will be molded and pressed, then fired, baked, sintered or cured. A complete blend of powder and binder usually produces a dry mix. When it is thoroughly dispersed, the binder gets lost.

On the other hand, a partial coating of particles by adherent clumps of the binder tends to produce agglomerates. These clusters or granules of partially mixed material are easy to handle; they mold well and they also produce excellent end products.

The More the Better

Despite the interesting exceptions cited above, the general rule is that the more completely mixed the particles, the better. A perfect blend is almost always the goal of a mixing operation.

It may not be possible to attain the goal of perfection. Sometimes, even achieving a satisfactory blend is difficult. This means that a really accurate yardstick of quality is needed. Otherwise the decisions regarding what is "good enough" have no basis.

Lacking an objective standard, it's easy to waste time and money striving for impractical and unnecessary refinements. It's also possible to put up with substandard blender performance without being aware of the condition. As stated above, the quality of a blend should be judged against the needs of the product and against over-all costs.

Thus, a pigment dispersion that looks right in the end product and does not waste materials is satisfactory. A blend of process chemicals that serves economically in plant production is usually considered satisfactory. A blend of active and inert ingredients for a pharmaceutical product that assures there will be a uniformly safe, effective amount of the potent medicine in each patient dose will be a satisfactory blend.

Setting up a yardstick of satisfactoriness in terms of an end use is a helpful practice. It discourages the use of misleading criteria. There is always a temptation to regard completely random particle distribution as a sort of basic norm against which a blend might be judged and evaluated.

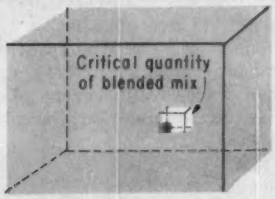
But, actually, this has very little economic justification.

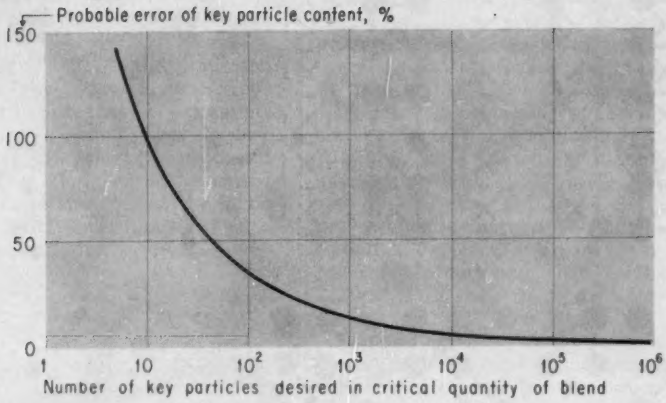
Superficially, the fact that a blend is achieved primarily by a random-motion flow process is a persuasive reason for adopting random distribution as a measuring stick. To do so, however, is to ignore all the other forces that modify the action of random motion. Many of these promote segregation and some of them promote completeness of mixing.

What Can You Tolerate?

The goal of pre-testing and of process engineering work is to put blending on a scientific basis. The first essential is to know what can be tolerated in the way of blend perfection.

Then, by selecting the most appropriate equipment and manipulating the process, it is usually possible to produce a satisfactory blend speedily and economically.





6—Limits to Theoretical Blends

The process design engineer must plan to combat the various limitations imposed by small-particle behavior.

Some common-sense, practical considerations are worth remembering when you relate a blend to its ultimate use. A helpful concept for evaluating the success of any blend is the idea of a "critical quantity" of blended material. You should be able to identify a "key material." Recognizing the limitations imposed by geometry and proportion will put the evaluation of a blend on a sound basis to begin with.

The Critical Quantity

Critical quantity is the smallest discrete amount of material that will affect the use of the product. It is the quantity that governs spot sample size. However, it retains its size and significance even though spot samples that are smaller or larger than the critical quantity may be submitted for quality control tests to determine blending effectiveness.

In a pigment dispersion, critical quantity is the smallest amount of paint or plastic in which effects of segregation or imperfect color matching can be detected by eye on the finished product.

In a medicinal product, the critical quantity is the smallest dose that will be administered—or a single tablet.

In an industrial process material, the critical quantity is the smallest amount of blend that will affect the process or the product adversely if it is improperly blended.

Recognize Key Particles

A *key material* is often involved in a blend, and the relation of *key particle size* to critical quantity is a very instructive one.

Key particles may be thought of as the active ingredients. For a color dispersion, they would be the pigment particles. The actual medicinal chemicals in pharmaceutical blends or the poisons in pesticide mixtures play these same key roles. So do adhesives in some cases, catalysts in others.

Many times the concentration of key particles must be small, 1-2% of the blend itself. It can be controlled very closely in a gross way by careful weighing or measuring while a batch is being charged. Multiplying this desired or charged concentration by the size of the critical quantity gives the amount of key material desired in the critical amount of blend.

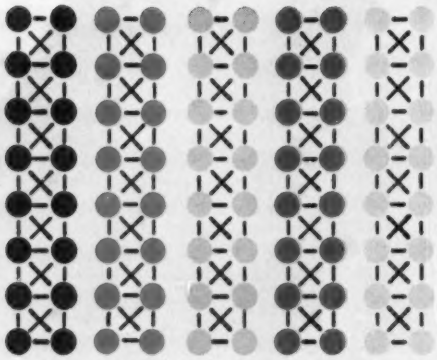
From a knowledge of approximate sizes of the particles that constitute the key ingredient, it's possible to compute the actual number of key particles desired in the critical quantity of blend.

Here is a number that may signal trouble if it is too small. In the reduction to absurdity, it may be necessary to put a single key particle in each critical quantity—or even a fractional particle!

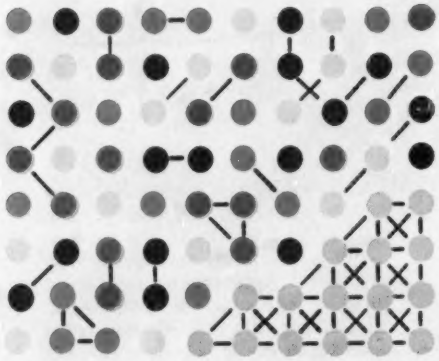
For practical purposes, any mix that would require fewer than 100 key particles in a critical quantity should be viewed with concern. In the graph on this page, we show in a qualitative way the relationship between probable errors that might be expected in a random distribution and the number of key particles/critical quantity. This curve can serve as a rough guide only because it assumes "randomness."

It's quite apparent that the key ingredient should ideally be broken down into the smallest, most uniform particles that can be handled in a practical blending operation.

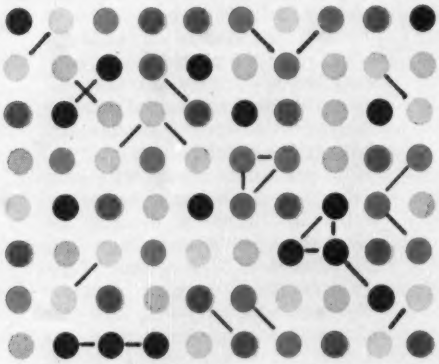
In a 50-50 binary blend, there are likely to be thousands or millions of key particles in the critical quantity. In a 1-to-99 blend, on the other hand, if the key material is the minor constituent, there will be one



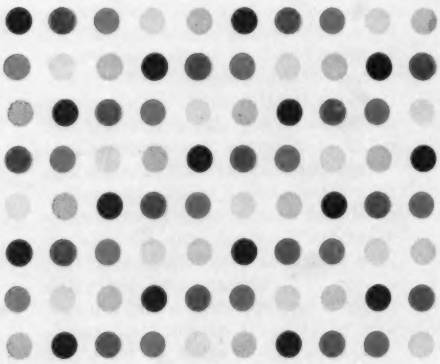
FIVE constituents of a blend, present in equal proportions, shown here in a completely stratified, segregated arrangement.



RANDOM dispersion still places identical particles in adjacent positions. In this view, one component is completely segregated.

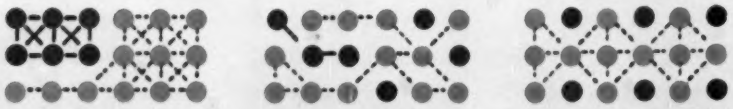


PARTICLES of the same kind frequently lie adjacent to each other, even in this random arrangement.



IDEAL arrangement, virtually impossible in blending experience, is achieved when similar particles are prevented from touching one another.

TWO-TO-ONE blending is shown below progressing from complete segregation, to random dispersion to perfect order.



fiftieth as many key particles needed for the same size critical quantity. A 0.1-to-99.9 blend cuts this to one five-hundredth.

Another factor in computing the number of key particles/critical quantity of blend is the critical quantity itself. This is determined by judgment and experience. If the target critical quantity is actually smaller than the true requirements of the product or process warrant, then excessively severe demands may be imposed on the blending process.

This can lead to frustration, wasted efforts and high costs without yielding any worthwhile benefit. At the same time, the critical quantity—and the corresponding spot-sample size—should be set at a small enough value to give a true picture of what is happening during the blending operation.

Consider the Alternatives

Alternatives to consider when process requirements call for too few key particles in a critical quantity are as follows:

1. Abandon the blending approach and introduce the key material in some other way. A particle counting or particle injection scheme may be worked out to accomplish this.

2. Blending can prove to be feasible in some cases if the key element is introduced as a solution in a liquid instead of as solid particles. Sometimes it may be combined chemically with another compound to gain the same results.

3. Stage blending and masterbatch techniques are helpful in overcoming the difficulties inherent in dispersing small quantities of active ingredients. But they, too, run up against a limit when each critical quantity of mix has to contain a mere pittance of key particles.

Multicomponent Blends

Multicomponent blends impose a limitation that may be more apparent than real. When a number of different types and sizes of particles are dispersed in a random arrangement, it must never be assumed that particles of the same material will always be separated from one another.

If a given particle is as likely to be one place as another, clumps of

the same material will invariably occur. Nonrandom phenomena, such as coating, can prevent clumps to a certain extent. They can also promote clumps.

The diagrams on the previous page show in one plane how it is possible for like particles to touch each other even in a lattice-ordered arrangement, if the proportions of the mix compel it. In three-dimensions, obviously, even more same-particle contacting can occur.

Recognition of the limitations imposed by geometry and proportion will put the evaluation of a blend on a sound basis to begin with. It will assist the process development engineer as he goes on to evaluate and combat the myriad other limitations imposed by small-particle behavior.

7—Sampling and Examining Blends

How many samples should you take? What should be the spot sample size? What about statistical techniques?

The most significant measure of quality that can be used for evaluating a blend is how it actually performs. If the blend works well in the production scheme and produces a satisfactory product, it is an acceptable blend.

While this generality provides the only valid final test, it offers scant guidance to the development engineer with a new process, or to the process control engineer responsible for keeping this step of his operations up to high standards. It is necessary, especially during early stages of new process exploration, to sample and test a blend to determine how good a blend it actually is.

How to Take a Sample

Taking a sample for checking purposes can be a very complex, statistically guided operation. It can also be as simple as scooping a bit of material out of a blender. Whether one sampling approach or the other is used depends on the type of blender being used and whether it is the blending equipment or the blend that is being evaluated.

Thorough sampling is usually necessary whenever the blender itself tends to segregate the mix. An example would be a blender so designed that it has pockets or "dead spaces" where random motion cannot occur. Another situation would be a blender designed to produce random motion in one plane but little or no motion along the third axis.

In cases like this, the purpose of sampling is twofold:

1. It can provide information about how the balance between blending and unblending forces has affected the mix.
2. It affords data on any segregation tendencies that may characterize the blending unit being used.

Therefore, the term "sample" in this case does not mean a single bit of material withdrawn from the mix. The word sample is used in its statistical sense to designate the significant facts determined from a number of spot samples withdrawn at the same time from different parts of a batch. Each spot sample is a bit of material which can be examined or analyzed in some way.

The procedure of taking many spot samples is very time-consuming and can be very costly. The procedure is seldom justified unless there is promise of some real benefit to be gained.

To remove samples from the interior of a mix without disturbing it, a number of "sampling thieves" have been developed. These devices are usually designed as rod-like probes with compartments that can be opened to receive small spot samples of the mixture, then closed again before the "thief" is withdrawn.

For many kinds of investigations, a sampling thief can be used advantageously. However, there are cases where the disturbance it creates in the mixture and the metal-ion contamination its opening and closing can introduce into the mixture and into spot samples will combine to make the use of such a device of doubtful value.

How Many Samples?

If the blender can impart completely random motion to the particles within it, it is only necessary to take enough samples to check segregation tendencies of the mix itself.

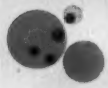
On the other hand, if particle motion is not completely random but affected in some way by blender configuration or design, then the sampling technique must provide ample warning of blender-characteristic segregation as well as particle-characteristic segregation.

Spot sample size should be no larger than the critical quantity —the smallest portion of the blend that will have any significance in use. This may mean taking a sample out of a sample to get a small enough bit of material in some cases.

If so, it will be important to perform the mechanics of sampling carefully to avoid accidental errors due to handling.

Checking the Sample

Measuring each spot sample for completeness of blending and compliance with requirements can be done in many ways. The ultimate in precision is to count all the particles of each type in the spot sample. Spot sample size must be fairly small with respect to particle size to make this counting operation feasible. Also, there has to be some way—usually visual—to distin-



guish one particle type from another.

Without performing an actual particle count, it's often very helpful to look at a portion of a sample under a microscope. From *X*20 to *X*100 magnification is most useful.

Laboratory techniques for analyzing solid-solid blend samples include dissolving and removing one of the constituents and weighing the residuum. Selective chemical reactions are also used to determine how much of each constituent is present in a spot sample.

Screen analysis has a limited usefulness. Even though the particle sizes of the materials to be blended are different enough to suggest this method, it should be used with caution. There must be no adhesion of particles, no granules made up of a number of particles and no breaking down of particles on a screen for this analysis route to succeed.

Tracers of various kinds have been used as an aid for analyzing blend samples. Their behavior can be very misleading. A tracer may well have a pattern of behavior characteristics (blending qualities) that are quite different from those in the actual blending mix.

Superficial examination with the naked eye should not be underestimated as an analytical tool. Gross divergences from good blending can be observed in many cases without even removing a sample from the blender.

Use of Statistics

Statistical techniques have been proposed by many investigators to guide the sampling and analysis of blend samples. Many authors have expressed the opinion that the use of statistical methods is more helpful than misleading, even though the statistical image is one of random distribution.

Sometimes this point of view is justified by the facts.

Greatest usefulness of the statistically derived values of variance and standard deviation is that they afford an honest way (statistically honest, that is) of comparing sample results.

Comparisons can be made from time to time as blending progresses, or tests can be made to evaluate effects of scale-up from laboratory blending to industrial-scale operations.

One way of making a comparison is simply to compute the ratio between two variances. Tables are available that enable the user to determine whether this ratio has real significance or whether a particular result may be regarded as a purely chance occurence. These tables are available in some texts on quality control.

Details of statistical techniques have been edited out of this report because of space limitations. A previous *Chemical Engineering* report has already covered this subject. (See "Industrial Statistics," by William Volk, *Chem. Eng.*, March 1956, p. 165; and the subsequent volume by the same author published by the McGraw-Hill Book Co., Inc. [1958].)

For further details on statistical techniques, the interested reader is referred to "Mixing of Solids," by Sherman S. Weidenbaum in "Advances in Chemical Engineering," Academic Press, Inc. (1958). A text cited in that publication "Introduction to Mathematical Statistics," by P. G. Hoel, John Wiley & Sons (1947), may also be of service.

It should be kept in mind whenever statistical methods are used that they are all based on assumptions that may not be justified in practical blending work.

They assume random arrangements and chance occurrences as norms. Actual particle arrangements are often far from random.

The value of a statistical approach is that it affords a measure of how much an arrangement departs from a random one and which way, whether it is more ordered or more segregated than chance alone would indicate.

8—The Practical Approach to Blending

The best general advice I can give is that static-free raw materials are essential to satisfactory blending.

When a new blending job is to be undertaken, there are several decisions that must be made. Equipment must be selected, procedures worked out and the blending cycle coordinated with other phases of production.

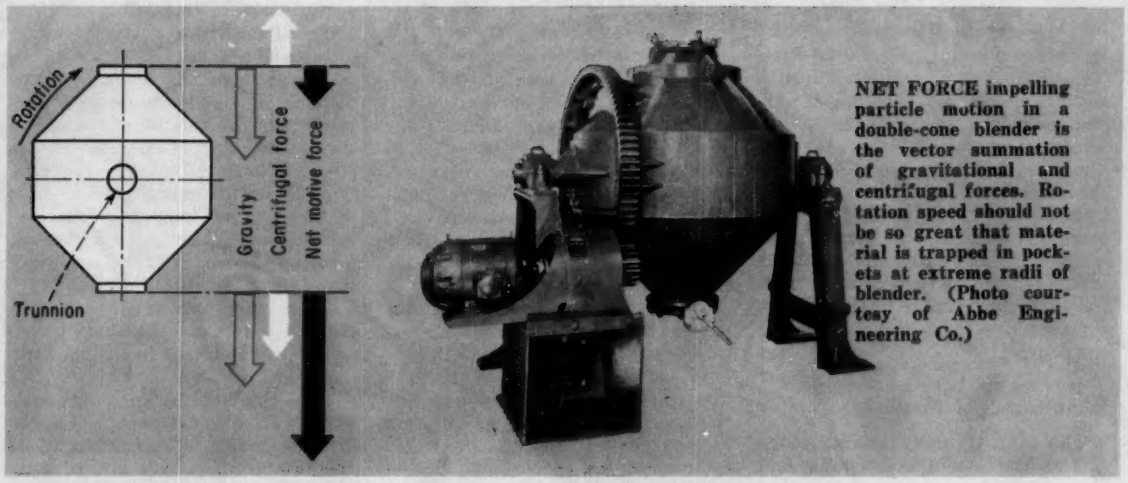
It has been the experience of the author's company that great savings of time and money can be achieved by pretesting in such a case. Solid-solid blending happens to be an operation that is admirably suited to scaling up from laboratory to plant-scale. Laboratory blenders are not difficult to use in simulating many plant situations.

The use of laboratory equipment for pretesting has often indicated changes of approach or equipment from that originally contemplated. These changes have brought blending jobs into successful production at considerably less cost and time than would have been necessary if the originally planned approaches had been used.

Laboratory equipment for blending evaluation consists mainly of small units of the same types that will be used on a plant scale.

Pretest Is a Preview

Comparison tests of different types of blenders are occasionally made to evaluate their relative performance on the same job.



NET FORCE impelling particle motion in a double-cone blender is the vector summation of gravitational and centrifugal forces. Rotation speed should not be so great that material is trapped in pockets at extreme radii of blender. (Photo courtesy of Abbe Engineering Co.)

At times, comparison may hinge not on the precise blending but rather on fitting a blending unit of a given capacity into a restricted space. At other times, materials handling may dictate the selection of a blender that will match existing facilities.

The important contribution of a pretest is that it affords a preview of the blending problem in combination. It reveals any peculiar properties of the solids themselves, discharge problems and material-handling problems.

Scale-up from laboratory size on tumbling units is very precise. As a matter of fact, the larger tumbler blenders generally have a higher blending efficiency than the smaller units.

Ribbon blenders do not scale up in direct proportion. The relative magnitude of the agitating surfaces is much larger in laboratory-size units than would be encountered in large production-size units. This problem is further complicated by the fact that horsepower requirements are difficult to predict, since power consumption depends not so much on blade surface and bulk density as it does on packing tendency of the material.

Power is not proportional to the relative blade surface either, but rather to the depth of submergence of the blade as it moves through the mass of material.

Other equipment important in a pretest laboratory will include facilities such as low-temperature dryers, moisture analyzers, a microscope for visual analysis of small portions of the blended material, etc.

If an electrostatic charge is suspected of hindering precision blending, it can often be dissipated by the uniform dispersion of a small quantity of water into the mixture. Then, to be in a position to finally evaluate whether this method could solve the problem, the material should be placed in the vacuum dryer before evaluating a final dry product.

While liquid addition and drying may not prove to be an economic solution, it does serve to pinpoint the source of the trouble. This can focus further efforts on measures designed to eliminate or minimize static charge build-up.

The main point in pretesting is to find the source of the blending difficulty, and to avoid a fruitless search for the ideal blender when the problem lies mainly with the solids themselves.

Short Times the Rule

Relatively short blending times with tumble blenders are the general rule. If a blend has not been achieved in five or ten minutes, it's usually a signal to stop and analyze what is happening.

Although further motion may be worth trying if the blend is getting steadily better, more probably some change in conditions will have to be made.

At this point, careful examination, thoughtful analysis and study can be more productive than immediate trial-and-error remedies. Examination may reveal that a minor ingredient may be coating another ingredient selectively. We might say that one ingredient is "gobbling up" another.

A symptom that invariably indicates electrostatic charge build-up is the coating of a blender shell with fine particles. Gross segregation is another signal.

When selective attraction is observed, it might prove helpful to omit the "hungry" ingredient. First, the minor component can be blended into the rest of the material. After it is uniformly dispersed, then the other ingredient can be added.

Another possibility is the addition of a dispersing additive. Wetting agents and detergents have been mentioned as being helpful in some cases. They can assist in combating electrostatic charge build-up. From all the various materials that can be used, it's sometimes difficult to select one that will do the job and will not introduce an objectionable contaminant into the blend.

A small quantity of water, uniformly distributed in the mixture might be a good first trial. Surfactants have proved extremely helpful in transforming smeary and agglomerated pigments into completely free-flowing materials.

It should be pointed out that

this surface treatment of pigments was successfully done on a laboratory scale to confirm our belief that many variables encountered in solids blending are a function of the electrostatic charge arrangements around the particles. It is not to be construed as a universally practical production solution, since in the initial stages of blending a typical pigment will adhere to all surfaces.

The adhering pigment must be scraped down periodically so that the surfactant can be uniformly incorporated with all the material in the charge.

Establishing a Method

The aim of many investigators in the field of solids blending has been to find a strong foundation amid the rubble of variables so that a scientific and predictable method of approach can be established.

Most promising approach to this simplification appears to be a thorough investigation of electrostatic charge phenomena. There is ample evidence that these almost innumerable variables—inhibited flow, bridging tendencies, smeariness, agglomerating tendencies, resistance to random distribution, segregating tendencies—are somehow tied up with the charge arrangement of particles.

If a method can be found to neutralize or control the charge arrangement, the number of variables in solids blending quickly boils down to particle size, shape, density and, possibly, surface characteristics. With three or four basic variables to contend with, the problem becomes completely manageable and a theoretical solution will merely be a question of time.

Look for Exaggeration

In retrospect, after years of pretest work with many combinations of solids used in many industries, we find that a useful clue to the solution of everyday blending problems can be found in the behavior of solids that exhibit exaggerated characteristics.

Careful analysis of all the blending problems we have encountered in our years of exposure leads us to a conviction that no single blender type is suitable for all blending operations. The chief function of a blender is to provide the flow conditions that induce efficient random distribution of the various components.

Since all types of blenders have a recognized acceptance in industry and have been used successfully to produce satisfactory blends, the chief function of a pretest is to select the best type for your particular operation. Whenever successful, well-proved blenders produce unsatisfactory results, it is either a case of misapplication of that particular type of blender or else the problem is not in the blender but in the solids combination.

If the problem is one of segregation, this is probably not going to be cured by going to a different type of blender. The solution would lie in changing the particle size of the components, producing granulations of the combination or perhaps, adding some third agent which acts as a bonding agent. The same applies to a precision blender such as the twin-shell or double-cone.

As we have indicated above, one of the simplest solutions in eliminating segregation is to reduce the solids to fine particle size. However, this can cause trouble if the reduction in particle size is achieved by mechanical methods that introduce electrostatic charge.

Static-free raw materials are essential to satisfactory blending.

How to Scale Up

Scaling up from laboratory to pilot-plant or production capacity equipment is straightforward with gravity, tumble-type particle blenders.

This is not always true of ribbon- or blade-type equipment, because the proportion of blade area to mix volume can change radically. However, in a precision tumble blender (such as a twin-shell or double-cone unit) the entire mass of material moves during each half revolution. This gives analogous conditions, whatever the dimensions involved.

Scale of rotation speed—which affects blending time—should be considered. In large units centrifugal forces at the extreme radii may approach the force of gravity. This would tend to trap a portion of the mix at each extremity of a vessel. Centrifugal forces should thus be kept within a practical limit of three-fourths to one-half the force of gravity.

The slower speeds involved will also contribute to gentler handling and will make for better blending of sensitive mixes.

Charge level in a tumble-type blender is usually designated as a percentage of the total volume of the blender shell. Generally, this is 65% of the total volume. Working capacity is always indicated in units of volume. But this should be considered only a nominal working capacity unless it is definitely established by pretesting.

Materials that have poor flow characteristics can usually be blended more effectively by using a reduced charge.

For example, because of the symmetrical shape of double-cone blenders, any charge in excess of 50% of the total volume will not be completely displaced in one revolution. With poor flowing materials, rated charge may provide zones at the trunnions where little or no flow would occur, and this may cause stratification at these points.

Attempts have been made to compensate for this by higher rotational speed to provide inertial flow. However, this can create other problems such as segregation by dusting out the fines.

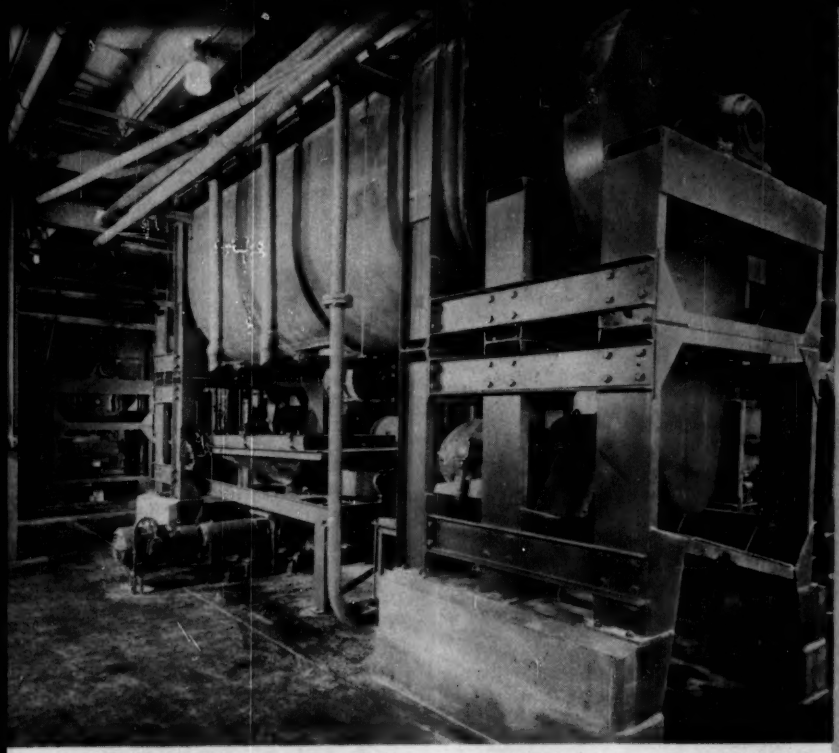
Consider Other Operations

Other operations that can be performed concurrently or in sequence with blending in the same vessel should be studied at the laboratory stage in preparation for planning the scale-up design.

Liquids can be introduced to solids after they have been blended, and this can be done in the same vessel. Agglomerates or granules of blended materials can be prepared this way.

Liquids or volatile matter can be removed in a vacuum blender, either at elevated or room temperatures. Sometimes this makes it feasible to remove any liquid that was necessarily introduced to achieve the blend. Vacuum drying has applications in many processes. Doing it in combination with the blending operation can cut plant equipment costs substantially. This scheme also frequently improves the product.

Chemical reactions are often run in blenders. Temperatures can be high or low, and heat can be supplied or removed. Particles can be reacted in a controlled atmosphere or under partial vacuum if desired.



RIBBON MIXER is the established, basic industrial tool used for solid-solid blending operations. (Photo courtesy of The J. H. Day Co.)

9—Equipment for Solids Blending

How to select the most satisfactory solid-solid blending equipment to meet your process design specifications.

There are similarities between solid-solid blending equipment and equipment used for blending liquids, slurries and pastes. Differences that are immediately apparent shed more light on the situation than the similarities, however.

Generally, the more mobile the mix, the less of it that must be moved by direct application of force.

Relatively small impellers stir up large volumes of liquid. Slurries and suspensions require larger impellers or more generally distributed moving mechanisms. Pastes are moved with a scraping, folding action, typically in a sigma-blade mixer. Mullers and kneading devices of many sorts work the same way, affecting a relatively small portion of the total batch at any one time.

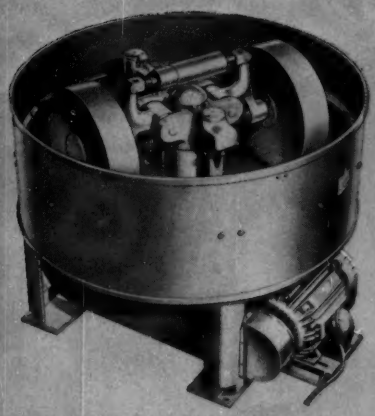
The most effective solid particle blenders, by contrast, apply a motive force (usually gravity) to the entire batch of material simultaneously.

Within this general reference frame, several types of blenders have been developed. Each has a place, and no single one is ideal for all operations. Also, there are many cases where units that have actually been designed around the needs of paste or slurry mixing are proving satisfactory for blending dry solids.

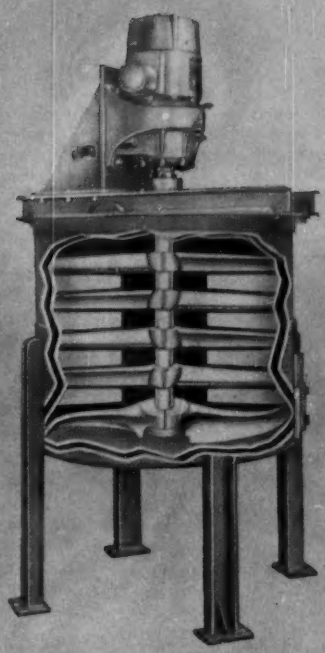
What Is the Ideal?

The ideal blender for handling solid particles would have a number of desirable qualities in perfect balance. Most important are:

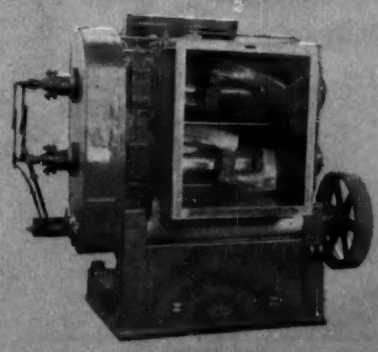
- Efficient mixing action. A complete blend should be attained rapidly.



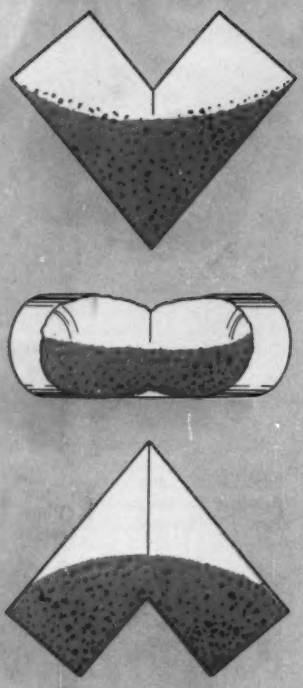
MULLERS are often used for blending foundry sands. (Photo courtesy of National Engineering Co.)



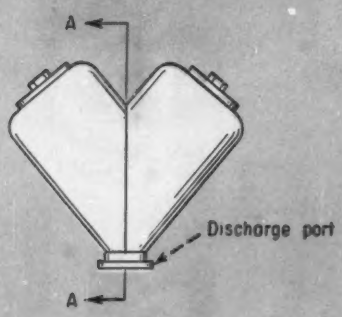
PADDLE mixers sometimes serve as solids blenders. (Photo courtesy of Charles Ross & Son.)



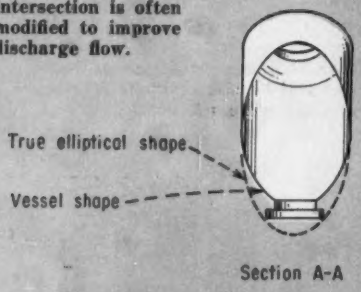
SIGMA-BLADE mixer: a pharmaceutical workhorse. (Photo courtesy of Baker Perkins Inc.)

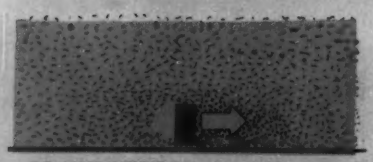


TWIN-SHELL tumble blender compels mass of particles to assume an entirely different cross-section at each rotation position.

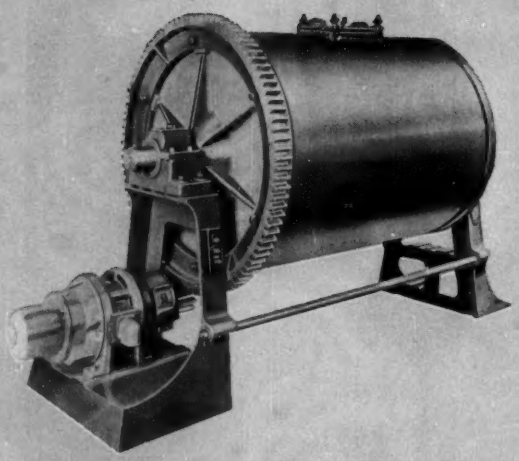


GEOMETRY of the intersection is often modified to improve discharge flow.





BLADE-TYPE blender creates motion in a small portion of mix at any time, leaves the rest of the mix relatively undisturbed.



DRUM-TYPE blender, at left, lacks good crossflow along its axis. Internal baffles or helical plates can be inserted to improve blending action. (Photo courtesy of Abbe Engineering Co.)

INTIMATE dispersion of solids and semisolids on a continuous basis is controlled by adjusting the angle of paddles and peripheral speed of blender shown at right. Ribbon blender at far right is used for blending small amounts of critical ingredients with a large basic material, in a minimum time. (Photos courtesy of Strong Scott.)

• Gentle mixing action. The unblending tendency created by mechanical work should be minimized.

• Cleanability. Interior surfaces should be accessible and free of crevices or elaborate mechanisms.

• Complete discharge. It should be possible to pour out the mix without hang-up.

• Dust-tightness. The blending process should be carried out in a completely sealed enclosure.

• Low maintenance. Need for repairs, adjustment and replacement of worn or broken parts should be kept at a minimum.

• Low power consumption. Less important for intermittent operation, power consumption can be significant in terms of heat and work imparted to the mass of particles.

• Low installed cost. Perhaps the least important of all, if the other factors are excellent.

This list may need modification if the blender is a multipurpose process unit. Some blenders also serve as particle-size modifiers, as dryers, as chemical-reaction vessels, etc.

Experience has shown conclusively that where the requirement is simply precision blending, the tumble-type blenders are much better than those with flights, paddles, blades or impellers.

Gravity action in all parts of the charge can be sustained more thoroughly, more gently, with less power and with less wear on the unit than mechanical pushing or scraping action. In such practical aspects as cleanability and ease of discharge, the tumble-blending unit presents fewer difficulties.

It is apparent, also, that a compromise must be made between blending efficiency (or particle mobility) and gentleness. The problem is to achieve maximum mobility with minimum scraping friction.

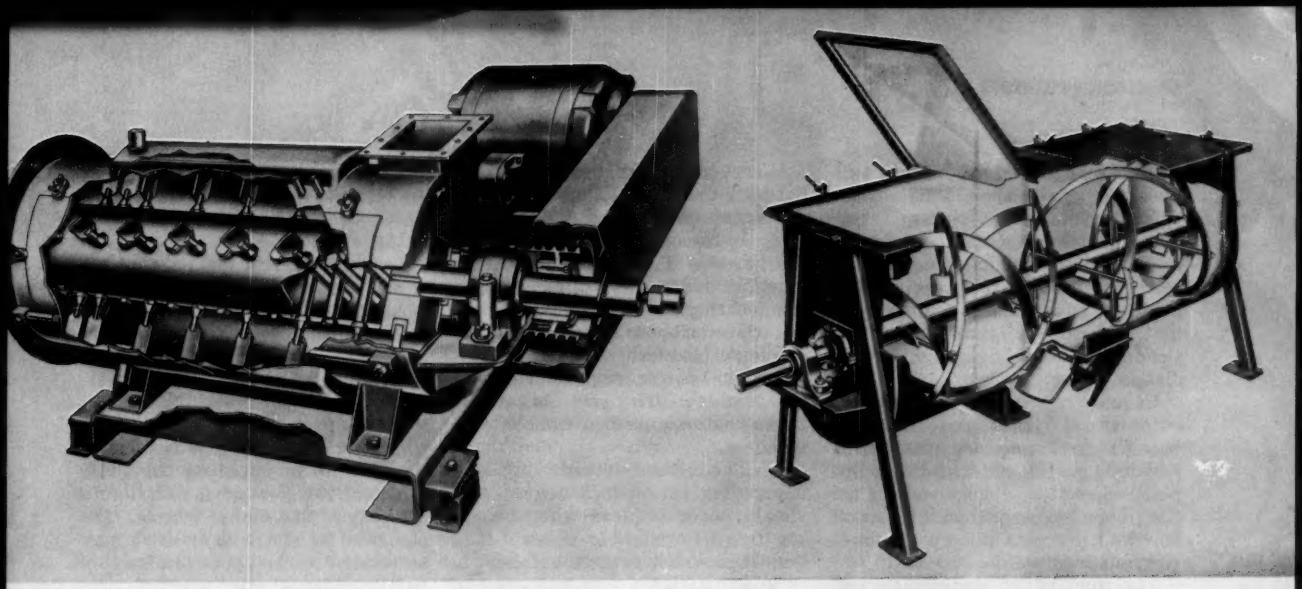
Drum-Type Blenders

Drum-type blenders with axis of rotation horizontal to the center of the drum are in common use. The basic limitation of this arrangement is lack of good crossflow along the axis.

Lack of changing flow cross-section, which would encourage the divergent flow of particles, means that mixing is achieved very gradually in stratified zones. The necessity for crossflow can be minimized by spreading all the components uniformly across the axis of the vessel.

Usually a drum unit is provided with internal baffles or helical plates to improve the crossflow. Charging or discharging is done through an adjustable chute, similar to that on a concrete mixer. This type of machine is generally not recommended for precise blending nor for applications where there is a cleaning problem.

Inclining the drum on its axis improves the mixing action without recourse to baffles. Such a blender usually has one or two inclined drums mounted on a driving frame. Large units of this design, when they are mounted permanently on an axis, are not practical because the entire contents cannot be discharged conveniently. How-



ever, the blending action is good as well as gentle.

Cubical-Shaped Blenders

Cubical- and polyhedron-shaped blenders of various kinds have been built with the rotating axis disposed at various angles with respect to the principal planes.

The fact that the vessels have flat surfaces discourages a rolling flow and substitutes instead a sliding flow. This is not conducive to the best mixing action.

While any shape will produce a mixing action to some degree, as long as flow exists, sliding flow does not contribute to mixing. When the particles slide they move in fixed relative positions to each other. Mixing only occurs when material drops or bounces from flat surfaces. Sliding also causes abrasion of particles against the interior of the vessel.

Furthermore, the many corners in a cubical or polyhedron-shaped blender make cleaning difficult. If the corners are rounded to avoid this difficulty, the construction becomes expensive.

Double-Cone Blenders

Double-cone blenders represent one of the commercially important types which were designed to overcome the limitations of some other kinds of blending equipment. The two cones are joined to a relatively short cylindrical section, and the axis of rotation is centrally located on the cylindrical portion.

The cones normally have a 90° included angle, or a 45° discharge angle, which is adequate for discharging most materials. If unusual materials are to be handled, the discharge angle can be made steeper.

This type of blender satisfies the basic requirement that a good blender must provide a constantly changing flow cross-section as the vessel rotates. Since the blender contains no flat spots, all the motion is rolling motion and good cross-flow is established by the interfolding action of the cones as material flows. And since the double cone is close to a sphere in shape, the power input at all angles of its rotation is nearly equal.

Because of the symmetrical shape of the double-cone blender, it is good practice not to charge it to more than 50% of its total capacity —in spite of the fact that all manufacturers list the nominal capacity at 65% of total.

The lower charge level assures complete displacement from cone to cone as the vessel rotates. A higher charge level can be tolerated, however, if all the components are extremely free-flowing.

Since the blender is normally free of baffles or other internal obstructions, a double-cone unit is easily cleaned.

Twin-Shell Blender

The twin-shell tumble blender is the other industrially important tumble-type blender. This unit is formed from a cylinder cut at an angle and joined together to form a "V" shape.

It provides a nonsymmetrical shape about the axis of rotation which is located at a point that provides equal torque loading throughout a full rotation.

The twin-shell blender combines the efficient blending action of the inclined cylinder with the intermeshing action that occurs when the two inclined cylinders combine their flows. The effectiveness of this intermeshing action makes the twin-shell the fastest of the precision blenders.

Manufacturing economy is enhanced by the fact that a long cylinder can be cut at an angle to produce the two sections. The "V" shape allows the use of large access covers at each leg. It also permits installation of a central discharge valve that will completely discharge all the contents.

Cleanability with this arrangement is excellent, particularly since all the interior surfaces can be reached through these access openings.

The shape of the twin-shell blender is also ideal when internal attrition devices such as the intensifier bar are used. Such components are easily removed from the outside through the large access openings.

Since shaft seals are essential for the high-speed internal agitator, the location of the access covers make inspection, adjustment or replacement of these seals a simple matter.

Ribbon Mixer: Basic Tool

The ribbon mixer is one of the oldest mechanical mixing devices used for solid-solid blending. Ribbon mixers are firmly established

as the basic industrial mixing tool (see photograph on p. 123).

A stationary trough-type shell (usually 2½ to 3 times as long as it is wide) with a semicircular bottom is fitted with a longitudinal shaft on which are mounted arms that support a combination of slender spiral ribbons, flights, paddles or helical screws.

Usual arrangement is to have an outer spiral ribbon move material in one direction and an inner spiral ribbon move the material in the opposite direction. This opposing of the ribbon helices provides for axial flow and prevents pile-up of material in one direction.

The amount of material moved by the ribbons is relatively small so that, in large units, blending cycles using ribbon mixers tend to be quite long. The outer ribbon must maintain a fairly close clearance with the semicircular cross-section of the shell bottom so that no undisturbed material remains on the bottom surfaces.

With solids that have only slight packing tendency, a somewhat more generous clearance will still scrub the surfaces clean. However, with fine solids that do not flow too readily, the possibility exists that a layer of material will remain undisturbed at the bottom.

A ribbon blender can be jacketed for heating or cooling and can be used effectively for mixing light pastes. Such a unit is also used for adding liquids to solids by mounting a battery of spray nozzles over the charge level.

Modified ribbon mixers can also be used for continuous mixing operations. Usually the shell is made much longer in proportion to its width, and paddles pitched to move the material ahead progressively may be substituted for ribbons.

At the discharge end, an adjustable dam plate is installed to control the rate of discharge while preventing the introduction of unmixed material into the discharge. Continuous mixers may also be jacketed for cooling or heating depending on the particular process.

Consider Pros & Cons

Chief advantage of the ribbon mixer lies in its stationary shell. This permits fixed charge and discharge connections and equipment installation in relatively confined spaces.

However, the simplified materials handling that a stationary shell provides may be assigned undue influence in the selection of blending equipment. This one advantage must be weighed carefully against some of these disadvantages:

- The ribbon mixer is not a precision blender.
- The power requirement for the same batch size is many times that required in tumble-type blenders.
- The ribbon blender imposes a grinding action to a degree and should never be used when blending fragile crystals or delicate materials in which particle breakdown is to be avoided.
- Excessive wear of the agitator surfaces can become a problem when handling abrasive materials. Those, such as fibers, that have a tendency to pack will demand tremendous power input with poor mixing results.
- Abrasive wear and power demands will be excessive on handling dense materials such as metal powders.

Of course, all of the above disadvantages can be overcome by special designs, but the question that should be asked is, "Is there a better way of doing this?" There are many noncritical blends for which the fact that a ribbon blender is not a precision blender need not be of any great concern.

Nevertheless, if it is essential to have a precise blend, then the ribbon blender may be ruled out.

Sigma Blades, Planetary Paddles

Sigma-blade mixers and planetary-paddle mixers are often used for solid-solid blending, but only as a step prior to the introduction of liquids.

Sigma-blade mixers, for example, are widely used in the pharmaceutical industry to incorporate a granulating solution into solids. The planetary-paddle mixer is used similarly. However, these units are not recommended for precision solids blending and they are primarily intended for liquid-solid blending or paste mixing.

Mullers for Solid Blending

Mullers are a highly specialized class of mixers. They have been firmly established as a standard in the mixing of foundry sands and have also gained wide acceptance in the ceramic industry for the preparation of clay-base mixtures with water.

Essentially, the muller consists of a circular pan with wide wheels mounted on vertically adjustable axles, connected to a central, vertical driving shaft. This shaft is usually installed through the bottom of a flat pan.

In addition, plows or scrapers which fit closely to the bottom of the pan are mounted on the shaft to direct the flow of material into the path of the muller wheels. The pan may be stationary; or it may be rotated in the opposite direction to the muller wheels.

Mulling action is a spatulate or smearing mechanism. This is achieved because the inner edge of the wide wheel travels a shorter circle than the outer edge, causing a degree of slip. The muller is an effective attrition device for breaking up caked material or incorporating pigments into solids.

If the wheels are adjusted for a close clearance with the bottom of the pan, the muller can even achieve grinding. Essentially, it is the closest mechanical approach to the time-honored mortar and pestle.

Mullers can be provided with jackets for heating and/or cooling, and on occasion they have been designed for vacuum operation. The mulling principle is very useful but highly specialized. Mullers are not recommended for simple solid-solid blending operations because:

- They are too expensive for this purpose.
- They are not precision blenders.
- There is too much attrition.
- Power consumption is high.

A Limited Choice

Selection of precision equipment for solid-solid blending, for all practical purposes, boils down to a choice between the twin-shell and the double-cone types. This rather dogmatic statement, it should be emphasized, does not apply "across the board" to all blending operations. It is restricted to consideration of dry, solid-solid blending operations only.

While the main application of these units is in providing precise and gentle blending, their range of application has also been extended by new developments. Their func-

tion now overlaps that assigned to other specialized types.

Here, judgment and experience are needed when specific applications are being considered.

One of the chief assets of tumble-type blenders is that the entire charge is turned over continuously as the blender rotates. With this basic advantage, it's possible to install a high-speed attrition device at the axis of rotation. Such a device, an intensifier bar, will provide varying degrees of impact (depending on the speed) to break up agglomerates. Intensive agitation near the surface of the charge, which is being turned over continuously, assures that all material will enter into the solid-solid contacting operation. Surface action provides the necessary impact, but it does so without excessive work input.

The intensifier bar in the twin-shell blender is removable. Rotation is powered by a separate motor so that mechanical work can be controlled. It is not always desirable to run the intensifier bar throughout the blending cycle. Chief function of the intensifier is to break up the agglomerates, and after this is accomplished the drive can be shut off.

This is particularly important when a minor component of low density and fine particle size is to be distributed in the batch. The intensifier will tend to segregate fines into a cloud of dust while it performs its function of breaking down the agglomerates.

After it is turned off, the normally efficient blending action of the tumbler alone can redistribute these fines.

Another modification of the basic tumbler allows the intimate dispersion of liquids in solids. One form uses a special spray nozzle introduced through one of the trunnions and held in a stationary position above the charge.

As the charge is turned over, it is sprayed continuously. Sometimes this arrangement is coupled with an internal attrition device. Other modifications that can be incorporated in tumble-blending units are: heating or cooling jackets; rotary-connected inlet connections for introduction of inert or sterilizing gases; and the installation of vacuum take-off connections with internal filter head and heating jacket to convert a basic tumbler into a vacuum-tumble-dryer.

In published comparison studies of various types of solids blenders, several arbitrary combinations of solid particles have been used as standards, usually to make analysis of spot samples easy. Such studies can lead to erroneous conclusions.

For example, a combination of ingredients may involve one component which contains soft agglomerates. These soft agglomerates may not be broken up in tumble-type blenders because of their inherently gentle blending action. But they do break up readily in equipment such as ribbon mixers that provide a degree of attrition.

Spot samples from the ribbon mixer would then obviously show a greater uniformity than those from plain tumblers. However, such an evaluation completely overlooks the fact that tumblers are available with attrition devices that are capable of producing far greater uniformity combined with complete control over the degree of attrition in the blend.

Such operations as pigment dispersion in solids can never be achieved in a ribbon blender alone whenever the mix must pass through a separate pulverizing stage. In a tumbler equipped with an attrition device, this can be done in one piece of equipment. Degree of attrition provided is a function of the speed of the attrition device.

The importance of the various modifications that can be made to the basic tumbler is mainly in its expanded capacity.

A Look at the Future

Improved blending equipment has been developed at a rapid pace during the last decade. It is reasonable to anticipate that this trend will continue.

A great deal of development work is being carried out by blender manufacturers and by investigators in companies that seek to blend their own products more perfectly. This work is bound to stimulate advances in techniques and in process equipment during the years ahead.

In this rapidly developing art of solid-solid blending, new equipment combinations will offer the chemical engineer further opportunities to improve processes while cutting down on costs and the number of units required.

10—Economics of Blending

Here's your working guide to the relative cost of various kinds of commercial blending equipment.

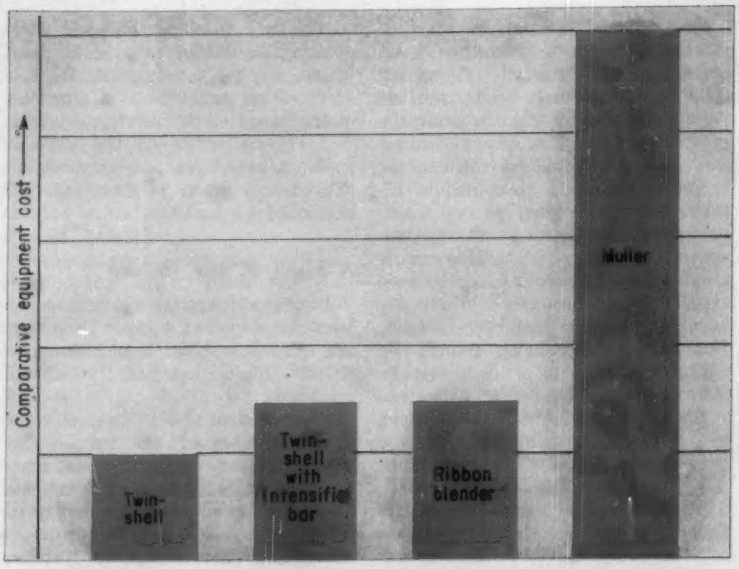
Economic advantages that can be gained by using modern blending equipment do not always include a saving in initial investment for the equipment.

Nor do the more costly units necessarily deliver better performance with dry solids. Generally speaking, heavier equipment, more power and more complex moving parts are needed for mixing pastes and dough-like mastics than for blending of dry solid materials.

With this in mind, some idea of the relative costs of the various kinds of solid-solid blending equipment available on the market today will prove helpful—if only to stimulate interest in comparison testing.

Based on Plain Tumbler

Using a medium-sized unit of from 30- to 50-ft. working capacity, with all parts in contact with the product to be constructed of Type 304 stainless steel, price compari-



APPROXIMATE RELATIVE COSTS shown above are based on blenders constructed of Type 304 stainless steel with a capacity of 30-50 cu. ft.

JOHN J. FISCHER is chief engineer of Patterson-Kelley's process equipment division in East Stroudsburg, Pa. Fischer was instrumental in creating and organizing this division and has been primarily responsible for the design, development and manufacture of specialized process equipment. He is a graduate mechanical engineer with more than 30 years of practical experience. In the past 15 years with P-K, Fischer has been granted six equipment patents and now has five patents pending in the field of solids processing. Before joining Patterson-Kelley in 1945, Fischer was employed by M. W. Kellogg as a supervisory design engineer on special projects.

sons can be made along the following lines:

1. The plain tumblers, such as the twin-shell or double-cone blenders will be used as the base-price item since they are the least expensive pieces of equipment.

2. A tumble blender of the twin-shell type with an intensifier bar attached costs 50% more.

For operating reasons, the intensifier bar is not recommended in a double-cone unit. The bar is removable for cleaning, and this can be accomplished conveniently in the twin-shell blender. Because of the limited access to the double-cone unit, a man must crawl into the vessel to remove the bar.

In addition, maintenance of the shaft seals—which should be inspected and replaced periodically—is equally inconvenient in the double-cone unit.

3. The ribbon mixer is priced at about the same level as the intensifier model twin-shell blender.

For such operations as pigment dispersion in solids, the cost of equipment for pulverizing or screening operations to size the solid raw materials must be added.

Other factors should also be considered in comparing the economics with the equally priced intensifier model twin-shell blender:

- Mixing cycles are much longer.
- Power requirements are about five times greater.
- Cleaning is extremely difficult.
- The muller-type mixer costs about five times as much as the plain tumbler. As has been indicated, the muller is not intended for general solids blending problems.

Mullers have their specialized applications, the need for which can be determined in a pretest laboratory. Where such a need is indicated, it can well justify the increased cost for equipment.

Consider Operating Costs

The financial outlay that must be made to purchase blending equipment, to install it and to provide all the related services, such as materials-handling devices, will undoubtedly receive close examination in any economic analysis.

However, when economic decisions are being made it's always prudent to look ahead to operating costs too.

Such factors as cycle time requirements and manpower required for cleaning can be translated into day-to-day or yearly operating expenses.

Reliability and reproducibility with which satisfactory blends can be achieved will be reflected in supervisory, overhead and sample-checking time. Reject rates and product quality will have their effect on over-all operating costs.

Estimates of how these variables affect the cost of plant operation can usually be made from data obtained during pretesting.

The more carefully these estimates are made, the more certain the likelihood of selecting the ideal blender for a specific task becomes.

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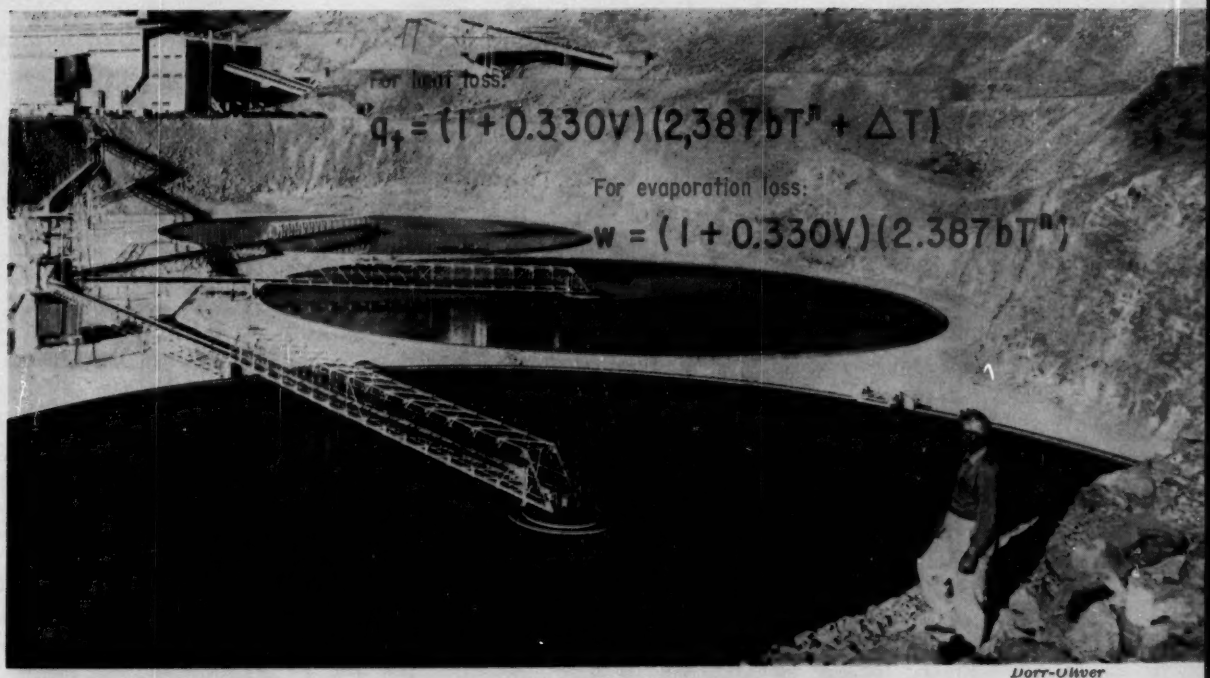


For Heated Ponds and Thickeners:

How to Calculate Heat, Water Losses

Here's a handy method for calculating heat and evaporation losses from high-temperature ponds and thickeners—increasingly important equipment in metallurgical processing.

B. L. THOMAS, Bedell & Nelson Engineers, Inc., New Orleans, La.

We have derived equations, based on theoretical considerations, which give excellent estimates of vaporization and heat losses from heated, open ponds and thickeners.

No satisfactory correlations exist in the literature for calculating such losses. This is a considerable handicap when working up a heat and weight balance for an extractive-metallurgy process. A few empirical correlations have been derived and published mainly for hydrological purposes,[2] but it is doubtful that they are valid over the higher temperature levels found in many metallurgical and mineral-dressing procedures where ponds are used.

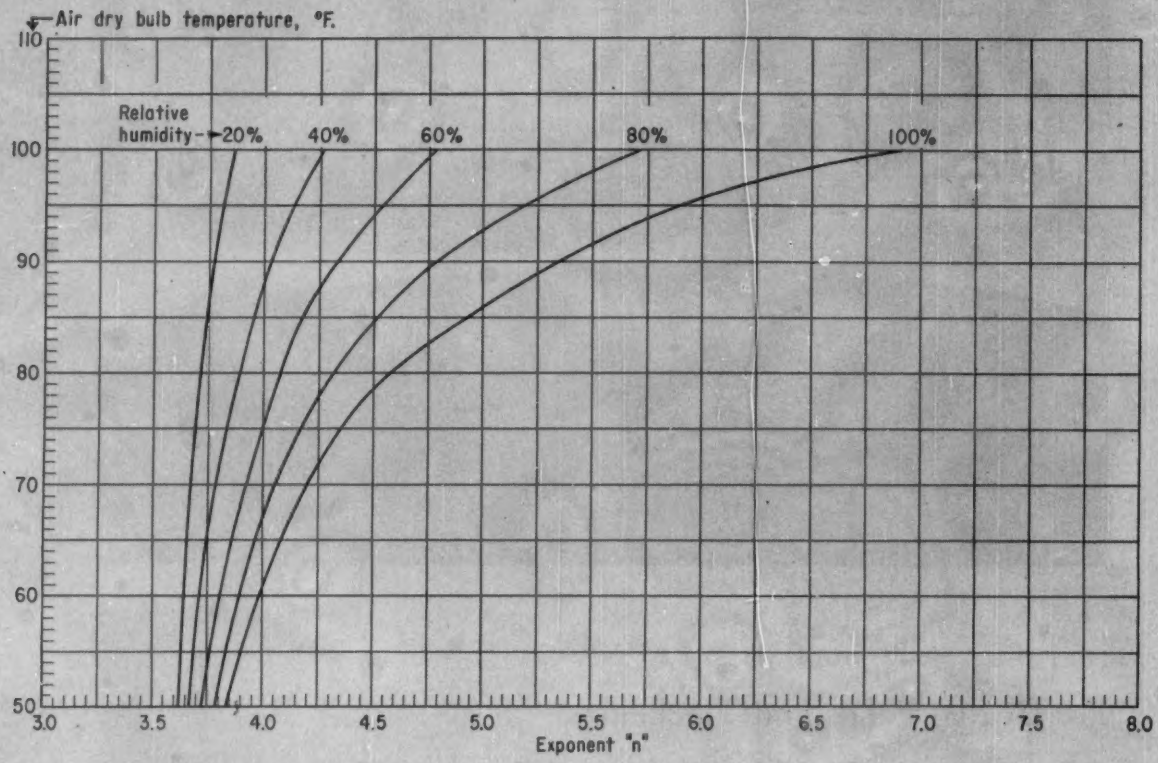
Consider Mass Transfer First

Let's first consider a large, open pond or thickener with a liquid surface area (A) exposed to the atmosphere. The basic mass-transfer equation is a well-known relationship:

$$W = k_g A\,(pp_1 - pp_2) \qquad (1)$$

Now, if water temperature is plotted on logarithmic graph paper against handbook values of $(pp_1\text{-}pp_2)$, the curve is almost a straight line. Deviation is very slight over the temperature range of 75 to 200 F. and for all practical purposes the curve may be considered a

Fig. 1—Knowing Relative Humidity and Atmospheric Dry Bulb, Curves Give Temperature Exponent *n*



straight line over this range, having the typical equation:

$$(pp_1 - pp_2) = bT^n \qquad (2)$$

Values of coefficient b and exponent n depend on the atmospheric dry-bulb temperature and relative humidity. A family of curves as shown in Figs. 1 and 2 has been developed for various atmospheric conditions, and appropriate values of b and n may be read from these curves.

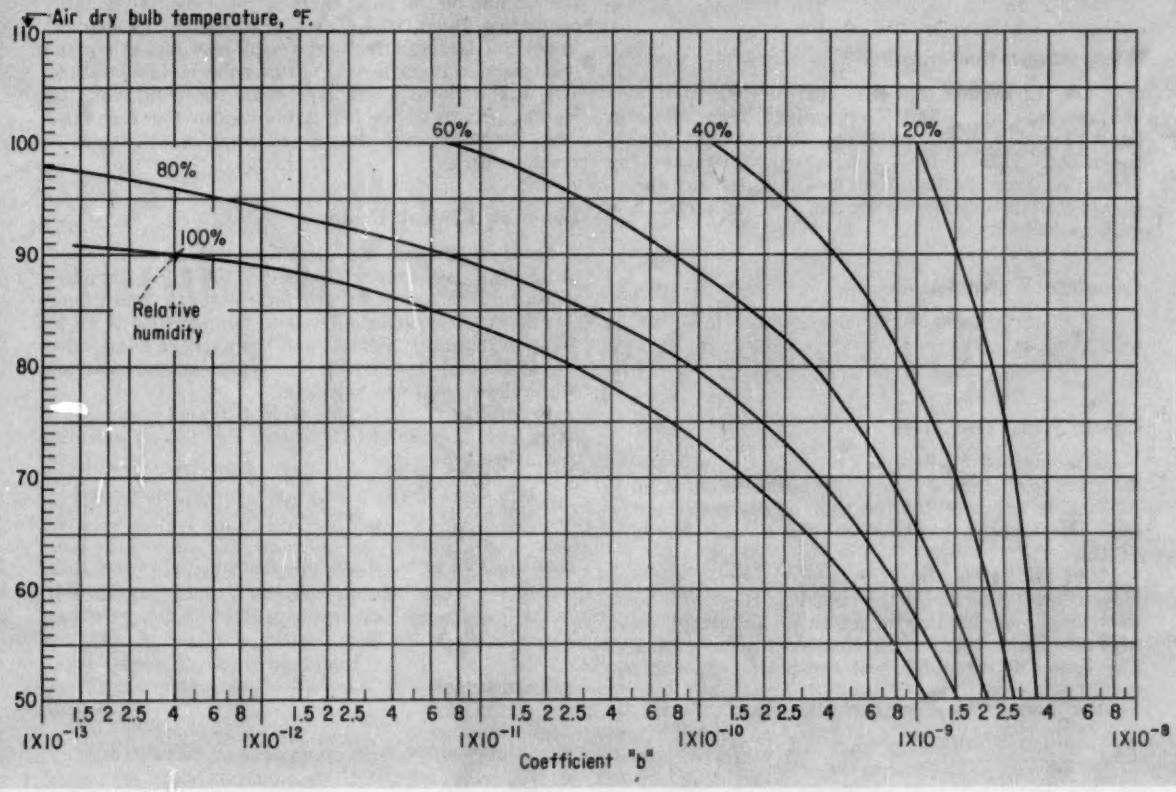
Substituting Eq. (2) into Eq. (1), we obtain the following:

$$W = k_g A b T^n$$

Nomenclature

A	Total liquid surface area of pond or thickener exposed to the atmosphere, sq. ft.
T	Temperature of fluid in pond or thickener, °F.
ΔT	Temperature difference between atmospheric-dry-bulb temperature and temperature of fluid in pond or thickener, °F.
V	Atmospheric wind velocity, mph.
W	Rate of vapor transfer, lb./hr.
b	Dimensionless coefficient.
h_g	Air-film heat-transfer coefficient from liquid interface to air, Btu./hr./sq. ft./°F.
k_g	Mass-transfer coefficient from liquid interface to air, lb.-mole/hr./sq. ft./mole fraction.
n	Dimensionless exponent.
pp_1	Partial pressure of water vapor at temperature of pond or thickener, atm.
pp_2	Partial pressure of water vapor in surrounding air at ambient temperature, atm.
q_c	Unit heat loss by conduction, Btu./hr./sq. ft.
q_e	Unit heat loss by vaporization, Btu./hr./sq. ft.
q_t	Total unit heat loss, Btu./hr./sq. ft.
w	Water evaporated, lb./hr./sq. ft.
λ	Molal heat of vaporization of water, Btu./lb.-mole.

Fig. 2—Correlations of Relative Humidities and Atmospheric Dry-Bulb Temperatures Give Coefficient *b*.



But if A is a unit area (1 sq. ft.), and λ is the latent heat of vaporization at temperature T, then by substituting:

$$q_e = k_g \lambda b T^n \quad (3)$$

Add Sensible Heat Loss

There will be, in addition to evaporative heat loss, a sensible heat loss by conduction from the body of hot fluid to the cooler air. This can be correlated for a unit area as follows:

$$q_c = h_g \Delta T \quad (4)$$

However, for air in motion over large plane surfaces it's known that[1]

$$h_g = 1 + 0.330\ V \quad (5)$$

Substituting this in Eq. (4) we obtain:

$$q_c = (1 + 0.330\ V)\ (\Delta T) \quad (6)$$

Total Heat Losses

Combining Eqs. (3) and (6), we have:

$$q_t = k_g \lambda b T^n + (1 + 0.330\ V)\ (\Delta T) \quad (7)$$

The only unknown term in this equation is the mass-transfer coefficient, k_g. This can be calculated from the air-film heat-transfer coefficient found in Eq. (5). According to the Lewis correlation for an air-water system,

$$\frac{h_g}{29\ k_g} = 0.26$$

or:

$$k_g = \frac{h_g}{(29)\ (0.26)} = \frac{1 + 0.330\ V}{7.54}$$

Substituting this into Eq. (7), and assuming an average value for λ of 18,000 Btu./lb.-mole:

$$q_t = \frac{(1 + 0.330\ V)\ (18{,}000)\ b T^n}{7.54} + (1 + 0.330\ V)\ (\Delta T)$$

$$= (1 + 0.330\ V)\ (2{,}387\ b T^n + \Delta T) \quad (8)$$

This is a final equation which may be used for calculating total heat losses from the surface of a heated pond or thickener. We have ignored conductance heat loss through the walls of the thickener, but it may be calculated by conventional methods. For buried ponds

or thickeners, heat loss to the ground will be negligible. If the temperature of a slurry in the thickener varies from top to bottom, obviously it is the top or surface temperature which should be used in Eq. (8) when calculating q_t.

What About Radiation?

It may be argued that this heat loss equation does not account for radiant heat gained from the sun during the day or radiant heat lost to the sky during the night. This is true, but in most instances fog formation over the liquid surface nullifies any radiation effect. In addition the air film also limits radiation gain or loss.

Calculate Water Losses

For material-balance purposes, water loss can be calculated as:

$$w = (1 + 0.330\ V)\ (2.387\ b T^n) \qquad (9)$$

Check With Test Data

Data obtained by Freeport Sulphur Co. on a 20-ft.-dia. test pond indicate that the heat-loss equation is reasonably accurate. At the time of the test the dry-bulb temperature was 60 F. with a relative humidity of 42%.

Wind velocity at the surface of the pond was considered negligible due to the shielding effect of a dense growth of surrounding vegetation. Tabulated below are calculated heat losses compared with measured heat losses at three different test-pond temperatures:

Pond Temp., F.	Heat Loss, Btu./Hr./Sq. Ft. Calc.	Actual
122	362	285
130	450	450
140	581	655

These differences are probably caused by inability to accurately measure small, variable air draughts at pond level. As shown in Eqs. (8) and (9), wind velocity has a marked effect on both vaporization and heat losses.

Combination of Mass Transfer and Conductance

To summarize, heat loss from the surface of heated, open ponds or thickeners is composed of two separate phenomena.

First, and foremost, is vaporization controlled by mass transfer, and second is conductance loss through the air film on the pond surface. Vaporization roughly comprises about 80 to 90% of the total. The most important factors affecting over-all heat loss at a given pond temperature are (1) atmospheric temperature, (2) atmospheric humidity, and (3) wind velocity. Radiation effects are negligible due to fog formation over the surface of the heated pond or thickener, in most cases.

Look at Typical Problem

Let's go through a typical calculation.

A continuous rotary thickener, 100-ft. in diameter, containing a slurry of ore and water is maintained at 180 F. Atmospheric-dry-bulb temperature is 90 F., relative humidity is 30%, and the average wind velocity at ground level is 5 mph. What is total heat and water loss from the thickener?

From Fig. 1, exponent n is 3.9 and coefficient b from Fig. 2 is 8.0×10^{-10}. Use Eq. (8) to calculate the over-all unit heat loss:

$$\begin{aligned} q_t &= [1 + (0.330)\ (5)]\ [(2{,}387)\ (8.0 \times 10^{-10})\ (180)^{3.9} + 90] \\ &= (2.65)\ [(19.096 \times 10^{-7})\ (6.245 \times 10^{8}) + 90] \\ &= 3{,}390\ \text{Btu./hr./sq. ft.} \end{aligned}$$

Use Eq. (9) to calculate the over-all unit water loss:

$$\begin{aligned} w &= [1 + (0.330)\ (5)]\ [(2.387)\ (8.0 \times 10^{-10})\ (180)^{3.9}] \\ &= (2.65)\ (19.096 \times 10^{-10})\ (6.245 \times 10^{8}) \\ &= 3.16\ \text{lb./hr./sq. ft.} \end{aligned}$$

$$\text{Total heat loss} = \frac{(3{,}390)\ (\pi)\ (100)^2}{4} = 26.6 \times 10^6\ \text{Btu./hr.}$$

$$\text{Total water loss} = \frac{(3.16)\ (\pi)\ (100)^2}{4} = 24{,}800\ \text{lb./hr.}$$

What would be the corresponding losses if the slurry temperature were reduced to 110 F?

$$\begin{aligned} q_t &= (2.65)\ [(19.096 \times 10^{-7})\ (110)^{3.9} + 20] \\ &= (2.65)\ [(19.096 \times 10^{-7})\ (9.150 \times 10^{7}) + 20] \\ &= 516\ \text{Btu./hr./sq. ft.} \end{aligned}$$

$$\begin{aligned} w &= (2.65)\ (19.096 \times 10^{-10})\ (9.150 \times 10^{7}) \\ &= 0.463\ \text{lb./hr./sq. ft.} \end{aligned}$$

$$\text{Total heat loss} = \frac{(516)\ (\pi)\ (100)^2}{4} = 4.06 \times 10^6\ \text{Btu./hr.}$$

$$\text{Total water loss} = \frac{(0.463)\ (\pi)\ (100)^2}{4} = 3{,}640\ \text{lb./hr.}$$

Most of the correlations in the literature give lower values for the examples just given. For instance, the Langhaar equation gives a heat loss of 2,108 Btu./hr./sq. ft. for the first example, compared to our calculated value of 3,390 Btu./hr./sq. ft.

Actually, Langhaar is concerned with design of cooling ponds as substitutes for cooling towers. His equations are not verified for pond or thickener temperatures over 100 F.

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A SIX-ARTICLE SERIES ON
LOW-TEMPERATURE CONSTRUCTION MATERIALS

CARBON STEELS
ALLOY STEELS
STAINLESS STEEL
NICKEL ALLOYS
▶ ALUMINUM
COPPER

Aluminum Alloys

Tough and ductile down to −423F.

EDSEL W. JOHNSON, Aluminum Co. of America, Pittsburgh, Pa.

This is the fifth in the series of articles we are publishing on construction materials for low-temperature service, from subzero to the absolute zero. One remaining material, copper, will be discussed, and the final article will be a critique from a major designer of low-temperature process plants.—Editor.

Aluminum alloys have an unusual ability to maintain their strength, ductility and resistance to shock loading at extremely low temperatures. It is for this reason, as well as for their comparatively low cost, that these alloys have long been popular in the fabrication of low-temperature equipment. Other properties which make these alloys attractive for low temperatures are high conductivity and reflectivity, low emissivity and high strength-weight ratio. They are also non-sparking and have good corrosion resistance.

These alloys have found application in all phases of cryogenic materials processing—from heat exchangers to fractioning columns, from piping systems to storage tanks. Even before the commercial availability of some of the newer alloys, an entire tonnage oxygen plant and an airborne 1,700 gal. Dewar (a container with a double evacuated shell like a Thermos bottle) were built of aluminum alloys. More recently, aluminum equipment has been built for handling liquid helium—a real challenge.

A four-digit numbering system has been developed to identify aluminum alloys. The first digit indicates the alloying element, for example, the "3000 series" is aluminum-manganese, while the "5000 series" is aluminum-magnesium. The second digit shows a modification of the original alloy or impurity limits—a zero indicates no modification. The final two digits serve to identify the specific alloys within a group and are assigned arbitrarily as a new alloy is developed. The standard temper designation for aluminum alloys consists of a letter indicating the basic temper which is more specifically defined by the addition of one or more digits. Basic tempers are: O, annealed; F, as-fabricated; H, strain-hardened; T, heat-treated. The H is always followed by two or more digits. The first digit shows the specific combination of basic operations and the following digit or digits the final degree of strain hardening. H14, for example, indicates half-hard, strain-hardened only; H18 indicates full-hard, strain-hardened only; H22 indicates quarter-hard, strain-hardened and partially annealed and H34 indicates half-hard, strain-hardened and then stabilized.

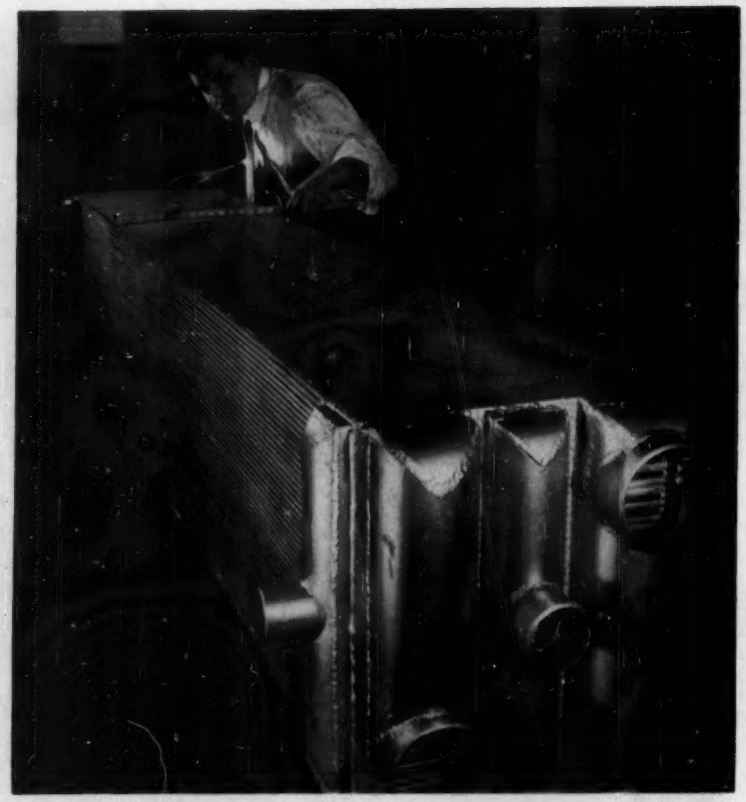
Much low-temperature equipment involves the design of pressure vessels of one kind or another. The tensile properties of welds are therefore of prime importance. This discussion will be limited mainly to those alloys which offer the most economy for welded construction when the equipment is to be used in the as-welded condition—the "5000 series." This series encompasses the aluminum-magnesium and the aluminum-magnesium-manganese alloys. Major constituent limits of these alloys are shown in Table I.

Stronger at Low Temperatures

Table II shows results of tensile tests on a few annealed aluminum alloys at low temperatures. As the temperature drops, tensile strength increases markedly—35-50% higher at −320F. than at room temperature. Tensile yield strengths are 15-25% greater. Elongations of

Mg and Mn Content of 5000 Series Alloys—Table I

Alloy	Mg, %	Mn%
5052	2.2–2.8	0.10
5083	4.0–4.9	0.4–1.0
5086	3.5–4.5	0.2–0.7
5154	3.1–3.9	0.1
5356	4.5–5.5	0.1–0.4
5454	2.4–3.0	0.5–1.0
5456	4.7–5.5	0.5–1.0



A BRAZED aluminum heat exchanger for five-way exchange.

these alloys also increase as the temperature drops to −320F., while reduction-of-area values increase down to −112F., but frequently decrease at lower temperatures. At −320F., however, the reduction of area is still about the same as at room temperature. Where such decreases occur they are accompanied by increases in elongation, indicating a large amount of uniform elongation. Table II also shows results of more recent tests on two alloys down to −423F. Table III lists ASME design stresses for several alloys in welded construction.

Tensile properties of welded aluminum alloy plate at temperatures down to −320 F. show that, as in the case of unwelded metal, strength and elongation increase with decreasing temperature. They also show that the strengths of welds in nonheat-treatable alloys are always at least equal to the strength of the annealed parent material.

Generally, the shear strengths of aluminum alloys at room temperature are about 60% of their tensile strengths. Double shear tests at −320 F. show that the shear strengths of the magnesium alloys increase at about the same rate as the tensile strengths—that is, the ratio of shear strength to tensile strength is about the same at −320F. as at room temperature.

The elastic moduli of aluminum alloys also, in general, increase as the temperature drops—about 12% at −320F., compared with room

Tensile Strengths at Subzero Temperatures—Table II

Temp., °F.	Alloy and Temper	Tensile Strength, Psi.	Yield Strength, Psi.	Elong. in 4D, %	Red. of Area %
75	3003–0	15,600	6,000	43.0	81
−112		19,000	7,300	45.0	80
−320		32,300	8,600	48.8	76
75	5052-H32	32,200	24,400	21.7	72
−112		34,800	24,300	26.3	74
−320		50,700	28,400	37.7	64
75	5154–H34	43,800	34,600	17.0	55
−112		45,300	35,400	20.5	64
−320		55,800	39,800	23.0	58
75	5086–H32	43,000	31,100	16.0	27
−112		46,900	32,200	23.0	45
−320		64,400	37,300	30.0	35
75	5454–H32	42,700	28,900	16.0	30
−112		45,500	30,300	22.5	44
−320		63,200	35,700	31.0	35
75	5083–0	45,400	21,800	23.0	35
−112		47,000	21,200	27.0	47
−320		62,900	23,800	33.0	38
75	5456–H321	57,400	39,500	14.5	....
−320		76,600	47,200	26.8	....
−423		94,500	51,500	15.6	....
75	6061–T6	44,900	40,800	13.8	....
−320		61,600	48,600	23.3	....
−423		75,800	55,300	18.3	....

ASME Design Stresses*—Table III

Alloy Designation	ASTM Designation	ASME Design Stress, 100 F.
3003	M1A	3,350
5052	GR20A	6,250
5154	GR40A	7,350
5454	GM31A	7,750
5086	GM40A	8,700
5083	GM41A	10,000
5456	GM51A	10,500
6061–T6	GS11A	6,000

* Welded construction.

temperature. There is little significant change in Poisson's ratio as the temperature drops.

Extensive fatigue testing of the alloys has shown that the fatigue strengths of smooth or notched aluminum alloy specimens at low temperatures equal or often exceed those at room temperature. Limited data on the new higher-strength aluminum-magnesium alloys show that the fatigue strengths average 15 and 25% higher at −320F. than at room temperature for plain and welded material, respectively.

Remain Ductile

One method of determining the resistance of metals to crack propagation is tear testing. The criteria for tear resistance are the loads and energies which initiate and propagate cracks in pin-loaded, notched specimens. Table IV shows results of tear tests on several of the 5000 series alloys. All of these alloys exhibited ductile fractures at low temperatures with no evidence of any transition in fracture behavior. In all cases, tear resistance was higher at −320F. than at room temperature.

Alcoa evaluated impact properties of several alloys with a falling-weight impact test. Here, the minimum height of drop of a given weight required to fracture a 16-in. octagonal plate resting on a vertical hollow cylinder is measured. Representative data for several plain and welded alloys show little or no loss in impact strength at −280F compared with room temperature. Where losses do occur, they seldom exceed 15%.

Good Thermal Properties

The instantaneous coefficients of linear expansion of alloys 3003 and 5056 are plotted in Fig. 1. Although the graph does not include some of the new higher-strength alloys, they should fall near alloy 5056.

Aluminum's low emissivity improves the effectiveness of insulation systems. Typical emissivity values are 0.011 at −452F., 0.018 at −320F. and 0.03 at room temperature.

Specific heat values for pure aluminum and for all the alloys listed in Table III fall within the width of the line on the graph of Fig. 2.

Fig. 3 shows thermal conductivities of a few alloys. While not all of the high-strength alloys are represented, their thermal conductivities should approximate those of alloy 5154.

Designed for Weldability

These alloys have been specifically designed to be weldable and to provide excellent mechanical properties in the as-welded condition. Experience shows the alloys to be about as adaptable as low-carbon steel to resistance welding, arc cutting and both tungsten-electrode and consumable-electrode welding. The welder may require special training, however, on consumable-electrode welding to control cracks in weld craters where a weld bead is terminated.

Formability of the alloys is approximately an inverse function of their strength.

Avoid Stress Corrosion

In stress corrosion, high enduring surface tensile stresses and a corrosive environment cause cracking. These stresses are usually residual—from fabrication or from faulty assembly. The environment need not be severe—cracking can occur without evidence of appreciable corrosion.

In the 5000 series aluminum alloys, susceptibility to stress corrosion results from a continuous grain-boundary precipitate which, in the presence of an electrolyte, is anodic to the grain. Formation of the precipitate depends on time, temperature, degree of work hardening and magnesium content.

Alloys 5052 and 5454 are not susceptible to stress corrosion. Alloys 5154 and 5086 are not susceptible when in an annealed condition, but, in a work-hardened temper, or with high enduring tensile stresses resulting from forming, they are not recommended for continuous service above 150F.

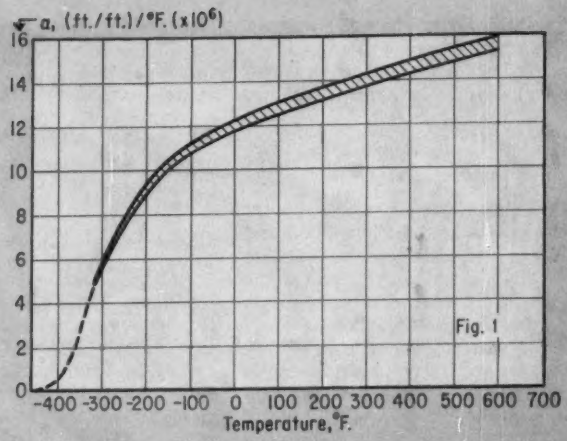
Alloys 5083, 5356 and 5456, because of their higher magnesium content, are less tolerant of work hardening and elevated tempera-

Results of Tear Tests on Some Aluminum-Magnesium Alloys—Table IV

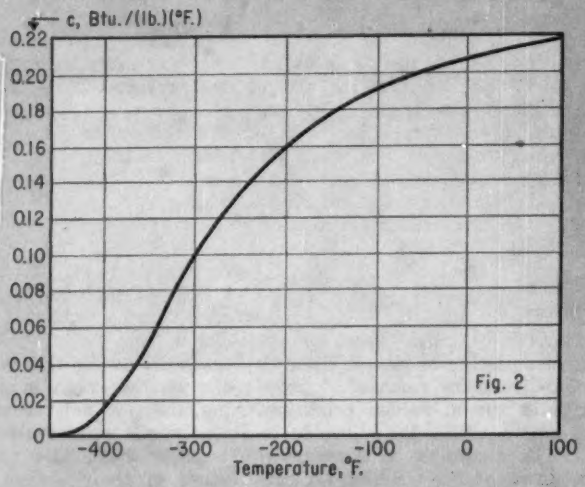
		Room Temperature				At −320° F.			
Alloy and Temper	Direction*	Max. Load, Lb.	Energy Required to Initiate a Crack, In.-Lb.	Energy Required to Propagate a Crack In.-Lb.	Total Energy, In.-Lb.	Max. Load, Lb.	Energy Required to Initiate a Crack, In.-Lb.	Energy Required to Propagate a Crack, In.-Lb.	Total Energy, In.-Lb.
5154-H112	L	1,335	50	97	147	1,740	93	198	291
	T	1,450	54	96	150	1,755	90	188	278
5356-0	L	1,245	66	148	214	1,370	84	190	274
	T	1,220	62	120	182	1,390	78	166	244
5356-H321	L	1,700	66	105	171	2,055	86	170	256
	T	1,605	46	66	112	1,880	52	98	150
5083-0	L	1,350	54	112	166	1,565	82	148	230
	T	1,350	56	96	152	1,540	62	132	194
5083-H113	L	1,650	45	112	157	1,900	58	133	191
	T	1,580	44	84	128	1,825	57	108	165
5456-0	L	1,290	44	98	142	1,450	52	121	173
	T	1,230	42	82	124	1,390	49	104	153
5456-H321	L	1,720	46	75	121	1,990	63	114	177
	T	1,550	35	62	97	1,810	42	66	108

* Longitudinal or transverse. All specimens plain plate, 0.10 in. thick.

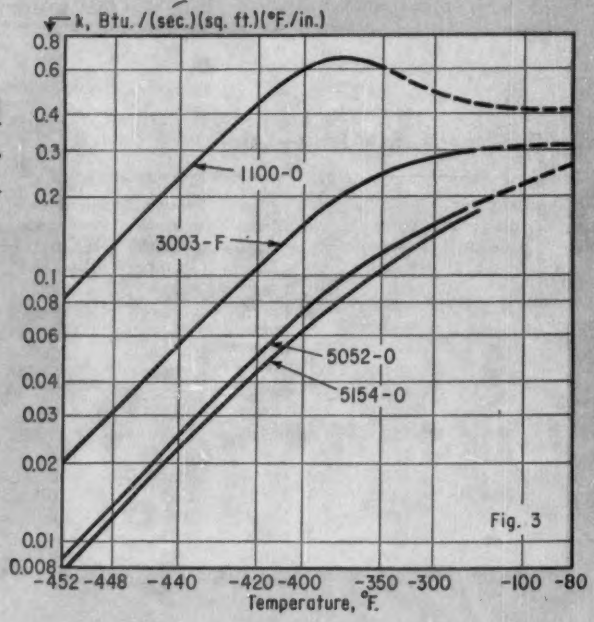
Linear Expansion



Specific Heat



Thermal Conductivity



tures. In tempers which suppliers recommend they are not subject to stress corrosion cracking at atmospheric temperature. Cold forming should be limited if no stress relief is planned. Alcoa recommends, for example, a minimum bend radius of 10 times the thickness for 5456 alloy in critical applications—where failure might have serious consequences.

Stress relief at 450F., plus or minus 25°, and forming at 425F. will remove or prevent the adverse effect of cold work on the aluminum-magnesium alloys.

Low Cost for Low Temperature

A study of material costs only for equivalent vessels in 5456 aluminum alloy, 304 and 316 stainless steels and copper showed 5456 to be least expensive of these materials. A subsequent survey of fabricators showed the cost of finished equivalent vessels to be substantially higher in the least expensive competing material than in 5456 aluminum. It is probably significant that all the firms quoting were experienced in aluminum fabrication.

The author wishes to acknowledge as material sources the Alcoa Aluminum Handbook; Technical Paper No. 14 by E. H. Dix, Jr., retired assistant director, Alcoa Research Laboratories; Alcoa Engineering Conference presentation by E. T. Wanderer, manager, petroleum section, Alcoa Sales Development Div.; Cryogenic Applications of Alcoa Aluminum.

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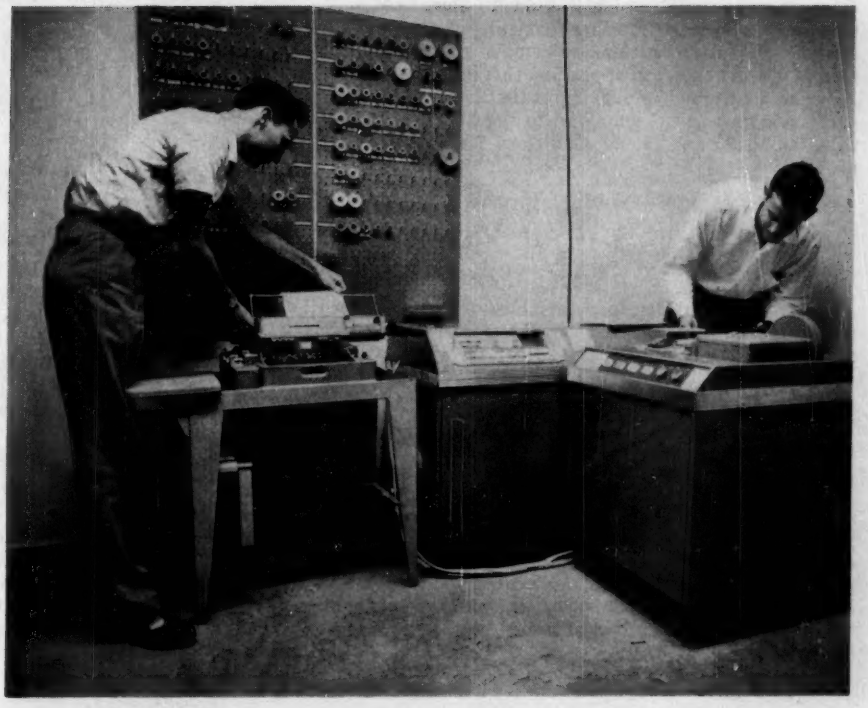

COMPUTER at the Rice Institute gives rapid results for the many iterations necessary in numerical analysis.

Find approximate answers to partial differential equations that result from unsteady-state heat transfer problems by using . . .

Numerical Mathematical Analysis

SAM H. DAVIS, JR., Rice Institute, Houston, Tex.*

Numerical approximations for the partial differential equations in heat transfer may be derived by the use of either polynomials in time and the coordinates or physical models of the actual problem. The latter approach has found extensive use by engineers and frequently leads to a better qualitative understanding of the problem than the mathematical approach. The use of a physical model is illustrated by examples included in Refs. 2 and 3.

Since the derivation of all previous approximations given in this series have used polynominals as a starting point, we will be consistent and use this same approach in the discussion of partial differential equations.

The one-dimensional heat conduction equation written in dimensionless form will serve as an illustration of one type of problem frequently encountered in unsteady state heat transfer. This equation has been derived in a previous article (*Chem. Eng.*, May 16, 1960, p. 151) and is given as:

$$\frac{\partial \theta}{\partial \phi} = \frac{\partial^2 \theta}{\partial \xi^2} \qquad (1)$$

where θ is a temperature difference ratio $(T - T_i)/(T_o - T_i)$, ϕ is at/L^2 and ξ is z/L. The symbol a is

* To meet your author, see *Chem. Eng.*, Apr. 18, 1960, p. 188.

the thermal diffusivity of the solid, z is the position relative to the center of the region and L is the distance from the center of the region to each boundary.

The particular problem of a solid initially at a uniform temperature T_o which is suddenly immersed in a fluid at temperature T will be considered because the analytical solution to this problem is known and the results of the numerical approximation may be checked.

If the heat transfer rate from the fluid to the solid surface is very large compared to the heat conduction rate, boundary and initial conditions for this problem are:

$$\begin{array}{lll} \theta = 0 & \xi = 1 & \phi \geq 0 \\ \dfrac{\partial \theta}{\partial \xi} = 0 & \xi = 0 & \phi \geq 0 \\ \theta = 1 & 0 \leq \xi \leq 1 & \phi < 0 \end{array} \qquad (2)$$

If the time and distance variables are divided into increments of uniform sizes $\Delta\phi$ and $\Delta\xi$ respectively, we may write:

$$\begin{array}{ll} \phi = s\,\Delta\phi & \phi_k = k\,\Delta\phi \\ \xi = u\,\Delta\xi & \xi_n = n\,\Delta\xi \end{array} \qquad (3)$$

The following abbreviation for θ at incremental values of the independent variables will be useful in future derivations:

$$\theta_{nk} = \theta(\xi_n, \phi_k)$$

Simplest polynomial approximation for the solution of Eq. (1) is first order in ϕ and second order ξ. If points which are symmetrically located about ξ_n, ϕ_k and ξ_m, ϕ_{k+1} are chosen to determine this simplest approximation, it would be of the form:

$$\begin{aligned} \theta \cong\ & \frac{(u-n)(u-n-1)(s-k-1)}{(-1)(-2)(-1)}\,\theta_{n-1k} + \\ & \frac{(u-n)(u-n-1)(s-k)}{(-1)(-2)(1)}\,\theta_{n-1k+1} + \\ & \frac{(u-n+1)(u-n-1)(s-k-1)}{(1)(-1)(-1)}\,\theta_{nk} + \\ & \frac{(u-n+1)(u-n-1)(s-k)}{(1)(-1)(1)}\,\theta_{nk+1} + \\ & \frac{(u-n+1)(u-n)(s-k+1)}{(2)(1)(-1)}\,\theta_{n+1k} + \\ & \frac{(u-n+1)(u-n)(s-k)}{(2)(1)(1)}\,\theta_{nk+1k+1} \end{aligned} \qquad (5)$$

That Eq. (5) takes on the values of θ_{sj} for $u = m$ and $s = j$ with $m = (n-1)$, n or $(n+1)$ and $j = k$ or $(k+1)$ may be seen by substitution. The analogy between Eq. (5) and the LaGrangian polynomial approximation given in a previous article in this series (*Chem Eng.*, June 13, 1960, p. 213) may also be seen.

An approximation for the partial derivative of θ with respect to ϕ may be found by performing the indicated operation on Eq. (5) and yields:

$$\begin{aligned} \frac{\partial \phi}{\partial \phi} \cong\ & \frac{1}{2\,\Delta\phi}\,[(u-n)(u-n-1)(\theta_{n-1k+1} - \theta_{n-1k}) + \\ & 2(u-n+1)(u-n-1)(\theta_{nk} - \theta_{nk+1}) + \\ & (u-n+1)(u-n)(\theta_{n+1k+1} - \theta_{n+1k})] \end{aligned} \qquad (6)$$

Similarly, an approximation for the second partial derivative of θ with respect to ξ may be found by performing this operation on Eq. (5) to give:

Centerline Temperature Ratios Calculated by Open Approximation—Table I

$\Delta\phi$	0.12500	0.06250	0.03125	0.03125	0.03125	0.015625	0.015625
N	2	2	2	3	4	2	3
ϕ							
0.125	1.00000	0.87500	0.86816	0.89711	0.87500	0.86533	0.89141
0.250	0.50000	0.64062	0.65456	0.66422	0.64062	0.66016	0.67119
0.375	0.50000	0.46680	0.48441	0.48582	0.46680	0.49250	0.49475
0.500	0.25000	0.34009	0.35753	0.35513	0.34009	0.36583	0.36394
0.625	0.25000	0.24777	0.26378	0.25958	0.24777	0.27151	0.26767
0.750	0.12500	0.18052	0.19460	0.18974	0.18052	0.20147	0.19686
0.875	0.12500	0.13152	0.14356	0.13869	1.13152	0.14949	0.14478
1.000	0.06250	0.09582	0.10591	0.10138	0.09582	0.11093	0.10648
1.125	0.06250	0.06981	0.07814	0.07410	0.06981	0.08231	0.07831
1.250	0.03125	0.05086	0.05764	0.05417	0.05086	0.06107	0.05759

$\Delta\phi$	0.015625	0.015625	0.0078125	0.0078125	0.0078125	0.0078125
N	4	5	2	3	4	5
ϕ						
0.125	0.90192	0.90707	0.86413	0.88881	0.89879	0.90364
0.250	0.67451	0.67593	0.66272	0.67425	0.67786	0.67942
0.375	0.49520	0.49536	0.49636	0.49904	0.49963	0.49985
0.500	0.36308	0.36265	0.36987	0.36825	0.36748	0.36709
0.625	0.26619	0.26548	0.27530	0.27165	0.27023	0.26955
0.750	0.19515	0.19435	0.20486	0.20037	0.19871	0.19793
0.875	0.14307	0.14227	0.15243	0.14780	0.14612	0.14533
1.000	0.10489	0.10415	0.11342	0.10902	0.10745	0.10672
1.125	0.07690	0.07625	0.08440	0.08042	0.07901	0.07836
1.250	0.05638	0.05582	0.06280	0.05932	0.05810	0.05754

$$\frac{\partial^2\theta}{\partial\xi^2} \cong \frac{1}{\Delta\xi^2}\,[-(s-k-1)(\theta_{n-1k}-2\theta_{nk}+\theta_{n+1k}) + (s-k)(\theta_{n-1k+1}-2\theta_{nk+1}+\theta_{n+1k+1})] \quad (7)$$

Eq. (6) might be expected to be a reasonable approximation for the partial derivative at the central point in space where $u = n$. At this central point, Eq. (6) reduces to:

$$\left(\frac{\partial\theta}{\partial\phi}\right)_{u=n} \cong \frac{\theta_{nk+1}-\theta_{nk}}{\Delta\phi} \quad (8)$$

Evaluation of Eq. (7) with $s = k$ gives:

$$\left(\frac{\partial^2\theta}{\partial\xi^2}\right)_{s=k} \cong \frac{\theta_{n-1k}-2\theta_{nk}+\theta_{n+1k}}{\Delta\xi^2} \quad (9)$$

while the evaluation of Eq. (7) at the midpoint in the time interval $(k + \frac{1}{2})$ gives:

$$\left(\frac{\partial^2\theta}{\partial\xi^2}\right)_{s=k+\frac{1}{2}} \cong \frac{(\theta_{n-1k}-2\theta_{nk}+\theta_{n+1k})+(\theta_{n-1k+1}-2\theta_{nk+1}+\theta_{n+1k+1})}{2\Delta\xi^2} \quad (10)$$

Use of the approximations given by Eqs. (8) and (9) in Eq. (1) leads to the iteration formula:

$$\theta_{nk+1} \cong \theta_{nk} + \frac{\Delta\phi}{\Delta\xi^2}\,(\theta_{n-1k}-2\theta_{nk}+\theta_{n+1k}) \quad (11)$$

Eq. (11) may be compared with Eq. (28) of the previous article (*Chem. Eng.*, July 11, 1960, p. 138) to show the similarity between this approximation and the zero-order approximation used in the solution of simultaneous ordinary differential equations. In this comparison, it is necessary to recognize that the numerical approximation for $\partial^2\theta/\partial\xi^2$ has replaced F_{nk} in the solution of simultaneous equations. Thus, the approximation given by Eq. (11) is first a substitution of a numerical approximation for the second derivative in Eq. (1) and second a numerical approximation for the resulting simultaneous ordinary differential equations.

Substituting Eqs. (8) and (10) in Eq. (1) leads to a closed numerical approximation given as:

$$-\beta\theta_{n-1k+1} + (1+2\beta)\theta_{nk+1} - \beta\theta_{n+1k+1} = \beta(\theta_{n-1k}-2\theta_{nk}+\theta_{n+1k}) + \theta_{nk} \quad (12)$$

where $\beta \equiv \Delta\phi/2\Delta\xi^2$. The similarity between Eq. (12) and Eq. (29) of the previous article (*Chem. Eng.*, July 11, 1960, p. 138) may also be seen.

The general method outlined in this section for the determination of numerical approximation to Eq. (1) can be modified to include higher order terms that were neglected in Eq. (5) of our original polynomial approximation.

Neither Eq. (11) nor (12) requires starting values of the dependent variable. Hence, these equations may be used to determine all θ_{nk}'s immediately from the initial condition given that $\theta_{n0} = 1$ except for $n = N$ where N is the number of subdivisions of ξ used in the approximation. For $n = N$, the second condition in Eq. (2) gives at $\xi = 1$, $\theta_{Nk} = 1$. The first boundary condition at $\xi = 0$ or $n = 0$ requires that $\partial\theta/\partial\xi = 0$. Since this second boundary condition was originally developed on symmetrical grounds about the center line, an equivalent expression is that:

$$\theta_{-1k} = \theta_{+1k} \quad (13)$$

The approximate solution of Eq. (1) as given by Eq. (11) requires solving the following equations:

Centerline Temperature Ratios Calculated by Closed Approximation—Table II

$\Delta\phi$	0.12500	0.06250	0.06250	0.06250	0.03125	0.03125	0.03125	0.03125
N	2	2	3	4	2	3	4	5
ϕ								
0.125	0.88235	0.86672	0.89365	0.90477	0.86393	0.88796	0.89783	0.90278
0.250	0.66782	0.66586	0.67794	0.68125	0.66532	0.67731	0.68114	0.68281
0.375	0.49807	0.49969	0.50257	0.50316	0.50001	0.50306	0.50377	0.50404
0.500	0.37089	0.37313	0.37167	0.37094	0.37366	0.37229	0.37159	0.37124
0.625	0.27614	0.27833	0.27479	0.27341	0.27887	0.27538	0.27402	0.27337
0.750	0.20559	0.20757	0.20316	0.20153	0.20806	0.20369	0.20206	0.20129
0.875	0.15307	0.15479	0.15020	0.14854	0.15521	0.15066	0.14900	0.14822
1.000	0.11396	0.11543	0.11105	0.10948	0.11579	0.11143	0.10987	0.10915
1.125	0.08485	0.08608	0.08210	0.08070	0.08638	0.08242	0.08102	0.08037
1.250	0.06317	0.06419	0.06070	0.05948	0.06444	0.06096	0.05974	0.05918

Values of Centerline Temperature Ratio Calculated With Eq. (23)—Table III

ϕ	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000
θ	0.908999	0.685446	0.504638	0.370777	0.272378	0.200090	0.146987	0.107977
ϕ	1.125	1.250	1.375	1.500	1.625	1.750	1.875	2.000
θ	0.079770	0.058269	0.042804	0.031444	0.023099	0.016969	0.012465	0.009157

$$\begin{aligned}
\theta_{0k+1} &\cong \theta_{0k} + (N^2\,\Delta\phi)(2\theta_{1k} - 2\theta_{0k}) \\
\theta_{1k+1} &\cong \theta_{1k} + (N^2\,\Delta\phi)(\theta_{0k} - 2\theta_{1k} + \theta_{2k}) \\
&\vdots \\
\theta_{N-2k+1} &\cong \theta_{N-2k} + (N^2\,\Delta\phi)(\theta_{N-3k} - 2\theta_{N-2k} + \theta_{N-1k}) \\
\theta_{N-1k+1} &\cong \theta_{N-1k} + (N^2\,\Delta\phi)(\theta_{N-2k} - 2\theta_{N-1k})
\end{aligned} \tag{14}$$

If the factor which multiplies θ_{nk} in Eq. (14) is negative, use of the approximation will lead to results which rapidly diverge from the true solution. This places the following restrictions on $\Delta\phi$:

$$\Delta\phi \leq \tfrac{1}{2}N^2 \tag{15}$$

For the case in which $\Delta\phi$ equals $1/2N^2$, Eq. (14) reduces to:

$$\begin{aligned}
\theta_{0k+1} &\cong \theta_{1k} \\
&\vdots \\
\theta_{nk+1} &\cong \tfrac{1}{2}(\theta_{n-1k} + \theta_{n+1k}) \\
&\vdots \\
\theta_{N-1k+1} &\cong \tfrac{1}{2}(\theta_{N-2k})
\end{aligned} \tag{16}$$

Eqs. (16) form the basis for the Schmidt tabular and graphical methods for unsteady heat conduction as illustrated in Refs. 2 and 3.

Analysis of Problem Shows Method

Solution of the problem considered in this article may be easily adapted for automatic computer calculations. The centerline temperatures calculated with Eq. (19) for $N = 2$, 3, 4 and 5 with $\Delta\phi = 0.125$, 0.0625, 0.03125, 0.015625 and 0.0078125 are given in Table I.

To see how the closed Eq. (12) may be solved in a systematic manner, it is convenient to write the equations as follows:

$$\begin{aligned}
(1+2\beta)\theta_{0k+1} - 2\beta\theta_{1k+1} &= c_0 \\
-\beta\theta_{0k+1} + (1+2\beta)\theta_{1k+1} - \beta\theta_{2k+1} &= c_1 \\
&\vdots \\
-\beta\theta_{N-3k+1} + (1+2\beta)\theta_{N-2k+1} - \beta\theta_{N-1k+1} &= c_{N-2} \\
-\beta\theta_{N-2k+1} + (1+2\beta)\theta_{N-1k+1} &= c_{N-1}
\end{aligned} \tag{17}$$

where the c_n's are quantities calculated from values of the dependent variables evaluated at earlier time intervals than $(k+1)$. An elimination and resubstitution process may be used to solve rapidly Eq. (17).

If the first equation in (17) is solved for θ_{0k+1} as:

$$\theta_{0k+1} = \frac{2\beta_{1k+1} + c_0}{1+2\beta} \tag{18}$$

Eq. (18) may be used to eliminate θ_{0k+1} in the second equation in (17) so that we find:

$$\left(1 + 2\beta - \frac{2\beta^2}{1+2\beta}\right)\theta_{1k+1} - \beta\theta_{2k+1} = c_1 + \frac{c_0\beta}{1+2\beta} \tag{19}$$

Eq. (19) may be similarly solved for θ_{1k+1} in terms of θ_{2k+1} and used to eliminate θ_{1k+1} in the third equation. After $(N-1)$ such eliminations, we have:

$$\begin{aligned}
\theta_{0k+1} &= d_0[2\beta\theta_{1k+1} + c_0] \\
\theta_{1k+1} &= d_1[\beta\theta_{2k+1} + c_1 + d_0c_0\beta] \\
\theta_{2k+1} &= d_2[\beta\theta_{3k+1} + c_2 + d_1\beta(c_1 + d_0\beta c_0)] \\
&\vdots \\
\theta_{N-1k+1} &= d_{N-1}[c_{N-1} + d_{N-2}\beta(c_{N-2} + \cdots + c_0)]
\end{aligned} \tag{20}$$

By the time the $(N-1)$ elimination has been completed, each θ_{nk+1} may be determined from the value of θ_{n+1k+1}. Since θ_{N-1k+1} is known explicitly then each θ_{nk+1} may be determined in order starting with the next to last equation in (20). The recursion formula for the determination of the constants d_n in Eq. (20) is:

$$d_{n+1} = \frac{1}{1 + 2\beta - \beta^2 d_n} \tag{21}$$

Eq. (21) requires that n is not equal to zero or one.

Values for d_0 and d_1 may be found by comparing Eqs. (18) and (19) with Eq. (20) and are given as:

$$d_0 = \frac{1}{1+2\beta}; \qquad d_1 = \frac{1}{1 + 2\beta - 2\beta^2 d_0} \tag{22}$$

Note that d_n depends only on n and β and would need be determined only once in the present problem.

The closed method outlined here was used to determine the centerline temperature of the solid with $N = 2$, 3, 4 and 5; and with $\Delta\phi = 0.125$, 0.0625 and 0.03125. The results of these calculations are given in Table II.

It is interesting to compare the centerline temperatures given in Tables I and II with the correct temperatures determined by a series solution for the same problem. For the centerline of the solid, the temperature as given in Ref. 2 is:

$$\theta(\phi, 0) = \sum_{j=1}^{j=\infty} \frac{(-1)^{j+1}4e^{-x}}{(2j-1)\pi} \tag{23}$$

where $x = [\tfrac{1}{2}(2j-1)\pi]^2\phi$.

Percentage Errors in Centerline Temperatures—Table IV
Calculated by Open Approximation

$\Delta\phi$ / N	0.125 2	0.062 2	0.031 2	0.031 3	0.031 4	0.016 2	0.016 3	0.016 4	0.016 5	0.008 2	0.008 3	0.008 4	0.008 5
ϕ													
0.125	10.01	−3.74	−4.49	−1.31	−3.74	−4.80	−1.94	−0.78	−0.21	−4.94	−2.22	−1.12	−0.59
0.250	−27.05	−6.54	−4.51	−3.10	−6.54	−3.69	−2.08	−1.60	−1.39	−3.32	−1.63	−1.11	−0.88
0.375	−0.92	−7.50	−4.01	−3.73	−7.50	−2.41	−1.96	−1.87	−1.84	−1.64	−1.11	−0.99	−0.95
0.500	−32.57	−8.28	−3.57	−4.22	−8.28	−1.33	−1.84	−2.08	−2.19	−0.24	−0.68	−0.89	−0.99
0.625	−8.22	−9.03	−3.16	−4.70	−9.03	−0.32	−1.73	−2.27	−2.53	1.07	−0.27	−0.79	−1.04
0.750	−37.53	−9.78	−2.74	−5.17	−9.78	0.69	−1.61	−2.47	−2.87	2.38	0.14	−0.69	−1.08
0.875	−14.96	−10.52	−2.33	−5.64	−10.52	1.70	−1.50	−2.66	−3.21	3.70	0.55	−0.59	−1.13
1.000	−42.12	−11.26	−1.91	−6.11	−11.26	2.73	−1.39	−2.86	−3.54	5.04	0.97	−0.49	−1.16
1.125	−21.21	−11.99	−1.49	−6.58	−11.99	3.77	−1.27	−3.05	−3.87	6.40	1.39	−0.39	−1.21
1.250	−46.37	−12.71	−1.08	−7.03	−12.71	4.81	−1.17	−3.24	−4.20	7.78	1.80	−0.29	−1.25

Since Eq. (23) is a series with terms which alternate in sign, the error in truncating the series after N terms can be no larger than the magnitude of the Nth term. Table III lists the values of θ at the centerline as calculated by using Eq. (23). In each case, the error in θ is no greater than one in the sixth decimal place. Therefore, these values may be used as references for determining the errors in numerical results. Tables IV and V list the percentage errors, expressed as $(\theta_{app.} - \theta_{act.})\ 100/\theta_{act.}$ for each temperature given in Tables I and II.

One strange result appears upon examination of the errors given in Table IV and V. This result indicates that in most cases a decrease in the time increment $\Delta\phi$ can increase the error in the calculated temperature if N is held constant. This appears to be a contradiction of what might be expected. Generally, the error in a numerical approximation can be reduced by reducing the size of the increment. However, the results shown in Tables IV and V are not as common as we might expect. There are several factors which can cause this increase in the error size. Among these factors are:

1. If the increment size is halved, the number of calculations which must be done to calculate the change in θ between an fixed limits of ϕ is doubled. Since during each such calculation only a finite number of digits can be used to represent numbers, some inaccuracy is introduced when the result of each operation is rounded to this number of digits. This round-off error tends to build up during many calculations and can outweigh the increase in accuracy achieved by the more accurate approximation given with the smaller time increment.

2. Numerical approximations for Eq. (1) represent two different approximations, one for the derivative with respect to time and a second for the derivative with respect to distance. The errors due to each of these approximations for any particular results may always be in opposite directions. If the error which is smaller in magnitude is then reduced, this would make the total error appear to grow.

3. Additional errors introduced by the time approximation are proportional to both some power of the increment size $\Delta\phi$ and to some higher derivatives of θ with respect to ϕ evaluated at some unknown point in the time interval. In the present problem a discontinuity occurs in θ at $\phi = 0$ and $\xi = 1$. Therefore, it might be expected that higher derivatives of θ with respect to ϕ at $\phi = 0$ might be very large but would die out as ϕ becomes large. As $\Delta\phi$ is made smaller, the increase in the magnitude of the higher derivative of θ could outweigh the decrease in the power of $\Delta\phi$ and giving again an actual increase in the error introduced in the calculations.

Round-off error in the solutions given in Tables IV and V is much too small to have caused the increase in errors observed as $\Delta\phi$ was decreased and can be eliminated as a possible explanation for these errors. The possibility of a cancellation between the errors from the different approximations may be checked quite easily for $N = 2$ by solving the equation in which the time derivative originally given in Eq. (1) is used with the numerical approximations for the space derivative Eq. (9). This gives the two simultaneous equations:

$$\frac{d\theta_0}{d\phi} \cong 4(2\theta_1 - 2\theta_0)$$

$$\frac{d\theta_1}{d\phi} \cong 4(\theta_0 - 2\theta_1) \qquad (24)$$

The solution of Eqs. (24) for θ_0 may be found analytically as:

$$\theta_0 = \frac{(2+\sqrt{2})e^{-y}}{2\sqrt{2}} - \frac{(2-\sqrt{2})e^{-z}}{2\sqrt{2}} \qquad (25)$$

where $y = 4(2 - \sqrt{2})\ \phi$ and $z = 4(2 + \sqrt{2})\ \phi$.

Values of θ_0 calculated by use of Eq. (25) are listed in Table VI. In all cases except for $\phi = 0.125$ and 0.25, the values of θ_0 (with N = 2) given in Table VI are always in the direction that the numerical approximations for θ_0 approached as $\Delta\phi$ was made smaller. The remaining apparent θ contradiction at $\phi = 0.125$ and 0.25 in Tables V and VI for the growth of errors as the time intervals were decreased can be explained by the discontinuity in θ at $\phi = 0$ and $\theta = 1$.

Percentage Errors in Centerline Temperatures—Table V
Calculated by Closed Approximation

$\Delta\phi$	0.125	0.062	0.062	0.062	0.031	0.031	0.031	0.031
N	2	2	3	4	2	3	4	5
ϕ								
0.125	−2.93	−4.65	−1.69	−0.47	−4.96	−2.31	−1.23	−0.68
0.250	−2.57	−2.86	−1.09	−0.61	−2.94	−1.19	−0.63	−0.38
0.375	−1.30	−0.98	−0.41	−0.29	−0.92	−0.31	−0.17	−0.12
0.500	0.03	0.63	0.24	0.04	0.78	0.41	0.22	0.12
0.625	1.38	2.18	0.89	0.38	2.38	1.10	0.60	0.36
0.750	2.75	3.74	1.53	0.72	3.98	1.80	0.98	0.60
0.875	4.14	5.31	2.19	1.06	5.59	2.50	1.37	0.84
1.000	5.54	6.90	2.85	1.39	7.24	3.20	1.75	1.09
1.125	6.97	8.52	3.50	1.74	8.90	3.91	2.14	1.32
1.250	8.41	10.16	4.17	2.08	10.59	4.62	2.52	1.56

Values of Temperature Ratio Calculated With Eq. (25)—Table VI

ϕ	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000
θ_0	0.893809	0.671734	0.501342	0.374052	0.279081	0.208223	0.155355	0.115911
ϕ	1.125	1.250	1.375	1.500	1.625	1.750	1.875	2.000
θ_0	0.086481	0.064524	0.048141	0.035918	0.026799	0.019995	0.014918	0.011130

Percentage Errors in Temperature Ratio—Table VII Calculated From Open Approximation

ϕ / $\Delta\phi$	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250
0.125	11.88	−25.57	−0.27	−33.16	−10.42	−39.97	−19.54	−46.08	−27.73	−51.57
0.0625	−2.10	−4.63	−6.89	−7.93	−11.22	−13.30	−15.34	−17.33	−19.28	−21.18
0.03125	−2.87	−2.56	−3.38	−4.42	−5.48	−6.54	−7.59	−8.63	−9.65	−10.67
0.015625	−3.19	−1.72	−1.76	−2.20	−2.71	−3.24	−3.78	−4.30	−4.82	−5.35
0.0078125	−3.32	−1.34	−0.99	−1.12	−1.35	−1.62	−1.88	−2.15	−2.41	−2.67

Error due to approximation for time derivative with $N = 2$.

Percentage Errors in Temperature Ratio—Table VIII Calculated From Closed Approximation

ϕ / $\Delta\phi$	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250
0.125	−1.28	−0.58	−0.65	−0.85	−1.05	−1.26	−1.47	−1.68	−1.89	−2.10
0.0625	−3.03	−0.87	−0.33	−0.25	−0.27	−0.31	−0.36	−0.41	−0.46	−0.52
0.03125	−3.34	−0.95	−0.26	−0.10	−0.08	−0.08	−0.09	−0.10	−0.12	−0.13

Error due to approximation for time derivative with $N = 2$.

Compare Approximations

To show how the different approximations for the time derivative alone compare, Table VII was constructed in which the percentage deviations between the temperatures listed in Tables I and II for $N = 2$ and the corresponding values of θ_0 listed in Table VII are given. Errors listed in Table VIII may be considered to be the error due to the approximation for the time derivative alone. The important result shown in Table VIII is the much smaller error given by the closed approximation than by the open approximation.

All calculations were performed by the "LGP 30" computer using programs which were arranged in almost identical fashion. The time required to complete each iteration with the program for the open approximation was found to be approximately $0.25N$ sec. The corresponding time requirement for closed approximation was $0.40N$ sec. To obtain results with the open approximation which have nearly comparable errors to those using the closed method and $\Delta\phi = \frac{1}{8}$ requires almost 10 times as much computation time. This is just one demonstration of the inefficiency of open approximations for solving differential equations.

It may also seem in Table VII that halving the time increment with the open approximation only resulted in a reduction in the error by a factor of two while a similar reduction in $\Delta\phi$ with the closed approximation reduced the error by usually a factor of four. For the solutions to problems which require very accurate results, the use of a closed first-order approximation would be expected to produce the required accuracy with even less than one-tenth the number of calculations used by Euler's approximation.

Some of the advantages of the closed approximation can be offset if the differential equation to be solved is nonlinear such as in heat conduction where a depends upon temperature. The iteration technique described previously for the solution of the closed equations will usually converge to the correct solution in no more than one or two trials. A theoretical discussion of the comparative merits of the open and closed approximations for the solution of unsteady heat conduction problems can be found in Ref. 1.

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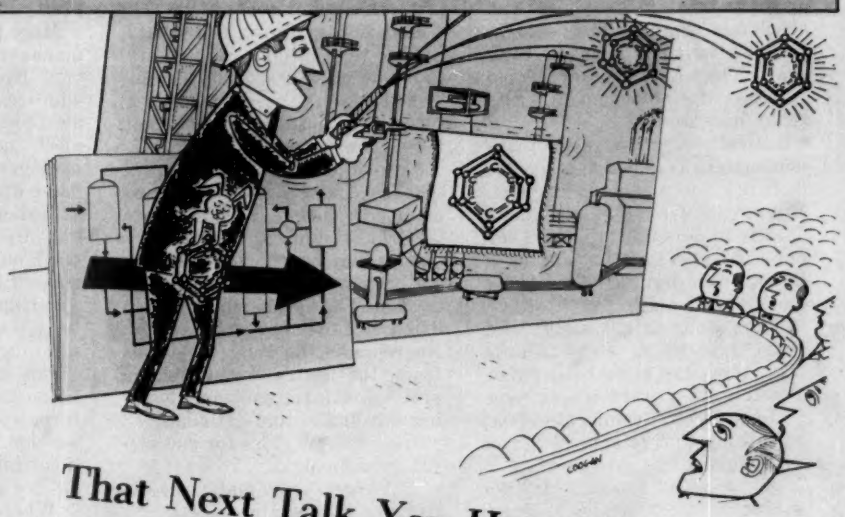


That Next Talk You Have to Give

Will your audience wish they had stayed at home or will they agree t... ...said was ... These 11 key points

Part of our American heritage is the priceless privilege of disagreeing with the opinions expressed by others. Here one expert reacts to another expert's article.*

Beware of the Expert Speech Makers

W. A. Sylvester, Editor, Technical Publications, The Standard Oil Co., Cleveland, Ohio

You're an engineer. So sooner or later you will give a technical talk. Whether it's a small talk for members of your company, or a full-dress performance for outsiders, you will do well to be wary of the advice from so-called experts in public speaking.

Sometimes the expert can help. But usually you'll do a far better job if you rely on your training as an engineer.

The expert's advice always sounds fine. It has the ring of virtue. He might tell you to: consider your audience; use simple words; organize your speech logically; avoid details; use effective gestures and voice levels.

This is good advice for the college freshman who tells his classmates "What I Did on My Summer Vacation." It's useless —if not worse—for an engineer. If you're fortunate enough to be a good speaker, great! Go to it!

But the chances are that you have enough problems on your hands with the technical material itself. Let me give you an example.

▶ **The Boss Was Right**—An engineer was asked to give a dry run of a speech for his associates before he delivered it outside the company. This engineer broke all the "rules."

He didn't look the audience in the eyes; he had a sing-song delivery and monotonous intonation; his speech was crammed full of hairy, technical details; and his colleagues nearly fell asleep.

Everybody agreed that the speech needed some pepping up; and everybody offered good, sound, traditional advice. Everybody, that is, except one person: the boss. The boss liked it, and the speech wasn't changed, not a single word.

An assertion of the boss's prerogatives? Another example of a man rising to power in spite

* Article in question is "That Next Talk You Have to Give," by Lawrence Murphy. See *Chem. Eng.*, Apr. 4, 1960, p. 151.

of a high lard-factor between the ears?

Not in the least. The big surprise was this: The boss was absolutely right. The speech, read as written, received high praise from the few key people outside of the company who really mattered.

▶**Basically Aggressive**—A technical speech is aimed at a specific audience for a specific purpose. Engineers do *not* listen to a speech to be entertained. They don't go to a meeting to see a lively, neon-lighted display of audio-visual aids.

They want to get some data, some experience, some results that they can't get otherwise. Possibly, they want to get some "off-the-record" comments about something that is not yet firmed up enough to go into print.

A technical speech is not meant to be "friendly." Every technical speech is basically aggressive, although people don't like to admit this. The speech, at least tacitly, is an assertion of the speaker's technical experience and superiority.

Criterion of success for a technical talk is not whether people enjoyed it, but whether certain people approved of it. Who? The people who can advance your status in the company, or the ones who have a financial relevance to your employer. Will these people acknowledge your technical competence?

▶**Let Them Yawn**—But suppose people do yawn? Suppose they say: "He knows his stuff, but he just can't put it across."

And if they do . . . so what?

The very people who decry your speech are actually admitting that your speech is really a success because it shows that "you know your stuff."

Now think of the so-called successful speech. You've heard many of them. The audience laughs at the jokes. They pay attention during the performance and they applaud loudly when it is over. The speaker has his ego lifted, but the net results are nil. No reprints, no congratulations from the man's superiors, no professional recognition. Nothing but smiles and oblivion.

Here are my rules for successful speechmaking:

1. Forget your audience; remember your engineering.
2. Use accurate words, not simple ones.
3. Don't organize your speech into logical patterns; organize your technical matters into patterns of technical relevance.
4. Cram your speech full of details, and good ones too.
5. Forget gestures. If your speech is really good, the audience will be taking notes and not looking at you.

And the final, rugged, decisive question is this: In my speech, what have I put that nobody else knows?

How to Sound Like a Manager

Author Sylvester now reveals the innermost secrets of successful managerial rhetoric.

Do you want to be a manager? If so, you must practice writing and speaking like one.

There are many ways to do this, but one in particular will raise the tone of your English at least a couple of pay-grades, and for very little investment of energy. Here is some practical, down-to-earth advice, from my experience as an editor.

▶**The Managerial Style**—The day of the hard-boiled, cigar-chewing, desk-thumping manager is over. Today's manager—in addition to being a practical man of affairs—sounds like a philosopher.

The manager sprinkles his speeches and his reports with words like "over-all planning," "framework," "objectives," or, fancier yet, "economic dynamics." These phrases are easy to use and they can be thrown in pretty much at random.

More particularly, though, the manager always adds a quote or two. He gives the impression of wide reading, of having a complex, philosophical setting for his most naive suggestions. The manager is not necessarily a name dropper but he is a highly skilled quote dropper.

▶**A Good Quote**—What is a good quote? It must be vague enough to offend nobody and reassuring enough to please everybody. Unhampered by precise meaning, a good quote is flexible.

For instance, the quote need be no longer than: "the only alternative is government intervention." The threat of government intervention is always useful for any manager.

Where do you find good quotes? There are three excellent sources of supply: *Harvard Business Review*, *Fortune* and almost anything written by Peter Drucker.

In *Fortune's* Apr. 1960 issue we find a perfect example on p. 284:

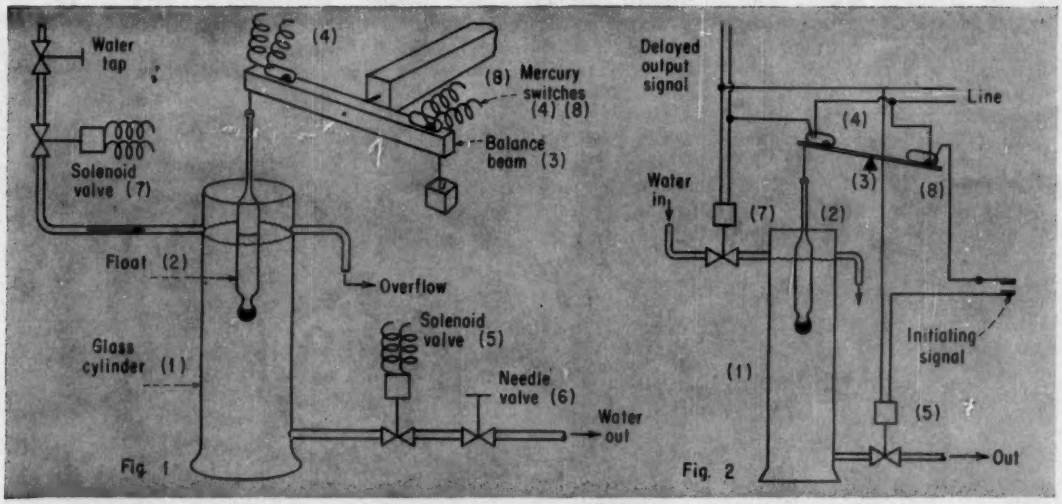
"For Americans, the ultimate softness, the ultimate smugness, the ultimate waste would be transferring to the government in the name of 'growth,' powers reserved 'to the people.'"

Use a quote like this and nobody will disagree with you. Nobody will ask what the quote means, and above all nobody will question whether you are being unfair to the article by taking the quote out of context. In fact, you can tell the audience that you are taking the quote out of context.

Here's how to tear a good quote out of context. From the Apr. 1960 issue of *Harvard Business Review*, we tore the following:

"Existentialism is not the only philosophical framework that has validity today, but the emphasis on self-knowledge, and the concept of responsibility, anxiety and guilt do provide a helpful, fresh approach to the meaning of life."

Try this one on for size. And your reader, or your audience still quivering from the word *existentialism* will not complain.



Water Flow Controls Time-Delay Relay

Adapting the principle of the ancient clepsydra this simple time-delay device needs little special equipment, adjusts from seconds to hours.

S. Sideman and J. Giladi
Department of Chemical Engineering, Israel Institute of Technology, Haifa, Israel.

Sometimes a control job requires a time-delay relay which may not be available when needed, so that an improvization becomes necessary. In such a case the variable time-delay relay which we built for one of our projects may easily be the answer, since it was constructed from odds and ends likely to be obtainable in any plant, while it could be set for time delays ranging from seconds to hours, with a maximum error of no more than 2%.

Frequently it is necessary to have a method of initiating some sort of action from seconds to minutes after receiving a signal from another action. There are several common methods of accomplishing this, for example, with resistance-capacitance electronic circuits; with thermal elements actuating relays; or with mechanical timers of one sort or another.

In our own case, we were pressed for time, while our budget was small, so we decided to use a modern version of the ancient clepsydra—or water clock. The idea was very simple—to actuate mercury switches by the rise and fall of a float supported by a column of water. The initiating action would open a valve, allowing the water column to start dropping. After a certain time, controllable by the rate of efflux, the output mercury switch would make contact and the output signal would be given.

In the sketches above, Fig. 1 shows the set-up, while Fig. 2 illustrates one possible electrical circuit. The body of our "clepsydra" consisted of a glass cylinder (1) with top and bottom inlet and outlet, and an overflow connection. A broken hydrometer (2) with a range of 0.9 to 1.0 sp. gr. served as the float. A balance beam (3) carried weights at either end, one of which was the hydrometer float.

Mercury switches (4) and (8) on the balance beam controlled the output signal and the resetting of the device after it had acted on a signal.

In the "start" position the cylinder is full of water. One way to operate is without the solenoid valve (7), in which case there will be a continuous flow of water into the cylinder at all times. In the preferred set-up shown, water flows in only until the cylinder is filled.

Assume a signal is received, energizing and opening the outlet solenoid valve (5) and allowing the water to start flowing out at a rate controlled by the setting of needle valve (6). After a time the level falls so that the beam (3) tips enough to make contact in mercury switch (4) while simultaneously it breaks the contact of switch (8). Switch (4) gives the desired time-delayed output signal, while switch (8) opens the circuit through solenoid valve (5) and stops the discharge of the water.

If solenoid valve (7) is omitted and water supply to the cylinder is thus continuous, then the time delay depends on the difference in opening of the inlet and outlet valves. For better control, however, we prefer to add a controlled inlet valve (7) which is in series with the mercury switch (4) so that, as soon as the time-delayed signal is given by switch (4), then valve (7) will open and start the refilling of the cylinder.

When the level becomes high enough to tilt the beam and break the contact of switch (4), then (7) will close and stop the entrance of water. At the same time, switch (8) remakes contact, thus resetting the relay ready to receive the next signal.

Repair Filter Leaves By Fabric "Welding"

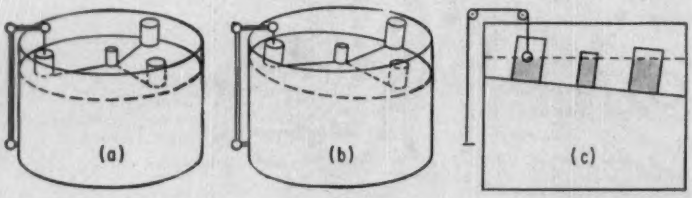
Robert W. Moore
Metallurgist, Attleboro Refining Co. Attleboro, Mass.

In one operation we use a Sweetland pressure filter with 36-in. leaves. In the course of time, small holes appear in the leaves, owing to cuts and abrasions in knocking the filter cake off. This resulted in considerable nuisance as long as we used standard sewing and repairing methods.

We found that nylon offered special ease of repair so we switched to it, thus enabling two men to repair the entire set of 70 leaves during the course of a single morning.

During the evening before the repair we had all the leaves washed in the press with a strong jet spray, then removed from the press. By morning the cloth was dry and reasonably clean. To repair a hole the workman would take a piece of clean nylon cloth and place it over the hole or tear in the leaf, applying heat with a standard heavy soldering iron. This readily welded the patch material to the leaf to give a tight seal which was mechanically strong and capable of lasting for many months more of service.

We've tried this method with other synthetic filter fabrics but nylon is the only one thus far on which it has worked successfully.



Connected oil drums (a) compensate for roof tilt (b). Sketch (c) shows how.

Taking Tilt Out of Gaging

At ISA's winter conference in Houston, J. P. Anthony, Jr., of Texas Instruments Inc. described a handy idea to compensate roof tilt in gaging large floating-roof tanks. If the gage tape is attached to the roof at one point, roof tilt may produce a sizable error. One way to rule out this error is to set three oil drums on the roof, connected together so that the level of liquid in all three will be the same. A float in one of the drums will thus show the *average* level of the roof.

Next Issue: Watch for Winner of Midsummer Contest

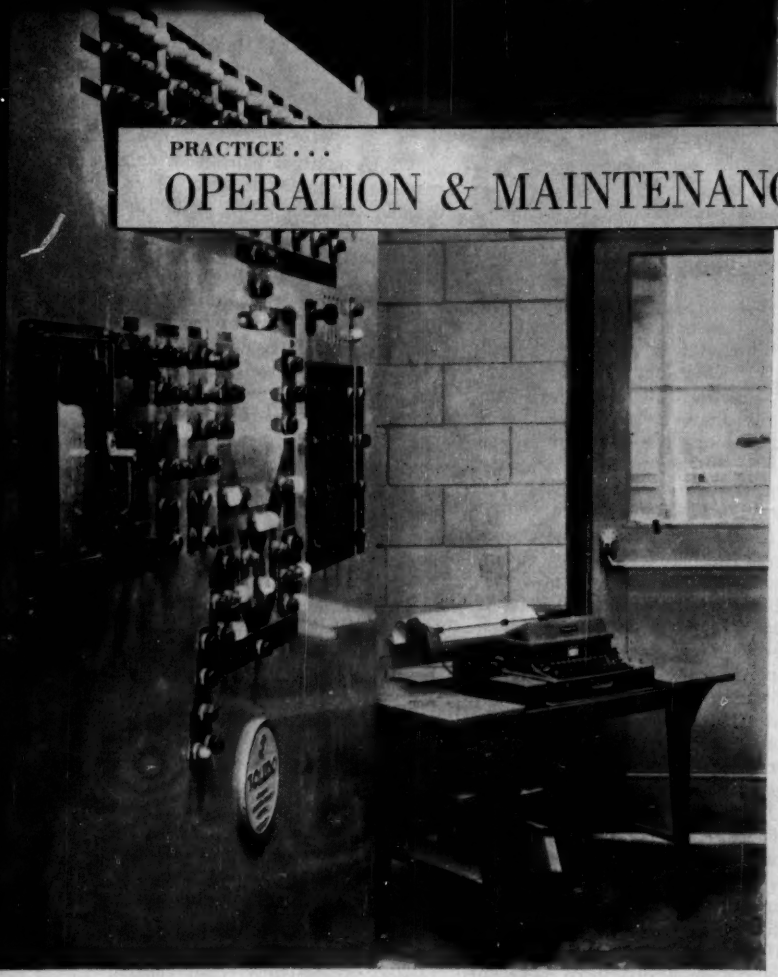
★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebooks. Each period's winner will be announced in the second following issue and published in the third or fouth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.



Think of Weighing For Process Control

Panel shows how sophisticated weighing has become; operator can control material flow from central point.

Richard Y. Moss, Vice President, Toledo Scale Corp., Toledo, Ohio

Weight is an integral part of any process: so many pounds go in here, so many pounds come out there. Cost of raw materials is measured in cents per pound as is the selling price of the finished product and the profit, if any. Thus accurate weight control is most important for a profitable operation.

If the feed materials and products are liquids or gases, accurate weight control is relatively easy. The process is probably well covered with instrument-controllers that continuously measure feed input quantity, process variables and product quantity and quality. If there are variations from the desired values, the controllers automatically adjust feed rates and process conditions to bring the product back to the proper quantity and quality. Such highly automated plants are common.

But if the materials involved are dry, the chances are that process throughput control is still rather primitive.

For example, feed materials probably flow from a hopper which may or may not be weighed. If it is not weighed, it is probably sight calibrated—it holds so many pounds when full, so many when half empty. If it is weighed, there is only an indicator showing the quantity left in the hopper. An operator controls the feed to the process by watching the weight indicator; there is nothing automatic about it.

It doesn't have to be that way. Weighing can be a process control tool as well as a mere indicator of quantities put into or taken out of a process.

▶**Scales Come of Age**—There have been greater advances in weighing equipment in the past ten years than in any similar period in history, particularly in the types of equipment that have most extensive application in the process industries. Potential for human error has been greatly reduced and the degree of automatic control greatly increased.

Perhaps the most pronounced trend today in the application of modern weighing equipment has been in the change from thinking of scales as somewhat isolated and unrelated units in the plant to the newer plant-wide concept of weighing.

Most of the components of any plant-wide weighing system are drawn from a limited number of basic scale types including hopper and tank scales, floor and built-in scales, portable and bench scales, truck scales, over-under zero scales, pan and laboratory scales. It is in the control and recording elements and the manner in which these components are integrated into systems, that particular progress has been made.

Completely identified weights can be printed at the scale on tickets, sheets or strips; graphic

recorders operated; material flow cut off automatically, and many more. Recording and control functions also have a part in remote recording and batch control equipment.

▶**Automatic Batch Controls**— The basic purpose of all equipment of this kind is to eliminate chance of human error and provide closer quality and quantity control. Additional objectives may also be better records and speeding the process.

The simplest automatic unit would be a single scale equipped with photoelectric or mercury cutoffs for a single ingredient. Greatest accuracy is achieved if these cutoffs control fast and slow feed respectively. The controls can either provide for an automatic repeat of the cycle, or be re-initiated by a push button.

Batching usually involves several ingredients. If the purpose of the multiple ingredient system is to repeat the same formula, a panel controlling the desired number of scales meets the requirements. Such a panel interlocks all gates, feeders and conveyors, introduces the ingredients in proper sequence and provides automatic cutoffs. You can also provide for stopping the operation, if there is a shortage of any ingredient, or for resuming the cycle following a power failure. Most panels of this type also have a light pattern indicating the progress of the cycle.

Remote setting automatic batching systems provide controls at the panel where you can make cutoff adjustments without going to the remotely located scale or scales. This gives ideal flexibility and convenience and it also permits a single weigh hopper to accumulate several ingredients for a more compact installation.

A number of special provisions to speed up operations are possible. For example, while one formula is being batched, another batch design can be preset on the panel. Or cutoffs may be preset where the nature of the ingredient would otherwise make accurate cutoff difficult.

The ultimate in automatic batch control systems goes an important step beyond the units described thus far. This next step eliminates the human element to a very high degree. Formulas may be preset on a board or plug and this preset element inserted into the control panel. These boards or plugs are designed to prevent accidental or intentional tampering so that they give positive assurance that the formula is introduced correctly. This advanced method of introducing the formulas has special merit where secrecy is a factor since the operator is not given the formula—he merely inserts the board or plug for formula 47, for example.

Automatic batching systems may include recording equipment. For example, it is now possible for each scale to read itself and transmit this weight to an electric logging typewriter for a record of each batch and the ingredients going into it. As alternates, printed records can be made at each scale, or graphic recorders can be used, or tape records automatically punched.

▶**In-Motion Weighing** — When items travel on an overhead track or conveyor or are subject to unusual vibration, as in testing, the problem of accurately recording weights without specifically stopping the item has always been difficult. A recent ingenious solution has been provided through which a scale is capable of making 10 successive scans of the indicated weight in approximately 2½ sec. and automatically averaging these into a single weight recording of high accuracy. These weights transmitted to an adding machine are then available as a list and a total.

▶**Automatic Bulk Weighers**— In the chemical process and food industries there is progress both in better packaging and in the better handling of materials in bulk. Two important weighing developments in the past few years that have made bulk weighing feasible in selling or buying operations are remote automatic listing and totaling, and provision for deducting any materials that may remain in a hopper after discharge.

A typical modern automatic bulk weighing system would consist of:

1. A dial type hopper scale with mercury switch or photoelectric cut-off.

2. A control console which may be remotely located. This console controls filling and discharge of a surge hopper and filling and discharge of the weigh hopper.

3. An electric adding machine is an essential element of the system. This automatically lists the gross weight of each hopper load and subtracts the weight of any material remaining in the hopper after discharge.

In operation, the desired number of weighments is set by turning a knob on the console. The system operates automatically until this number is reached.

▶**Automatic Conveyor Scales**— Analogous to the flow meters in a liquid pipe line are the automatic conveyor scales which continuously weigh material on a moving conveyor. These may be known as integrating scales, totalizers or other names, but there are only two basic types: totalizing conveyor scales and continuous weigh feeders.

Such a scale is necessarily quite complex. In addition to sensing the weight on the "live" conveyor section, it must integrate this weight with the belt speed taking into consideration any variations in the latter to arrive at the totalized weight. While weight data produced in this manner may not be as accurate as successive weighments in a hopper, it has practical advantages where large quantities of coal, ores and similar materials must be handled rapidly.

There are also applications for this general category of equipment where the objective is to obtain a continuous flow of material at a predetermined weight per minute. Materials flow from a supply source to the feeder with the feeder signaling any needed change in material flow to the supply source. This change of supply rate may be through operation of a gate or changing the speed of a vibrator. The nature of the material is important to successful operation of any feeder as a large lump can adversely affect the rate. The more uniform the material is, the better will be the results.

▶**Automatic Filling Controls**— Everyone is familiar with the old method of filling drums with

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human interests must balance technical efficiency

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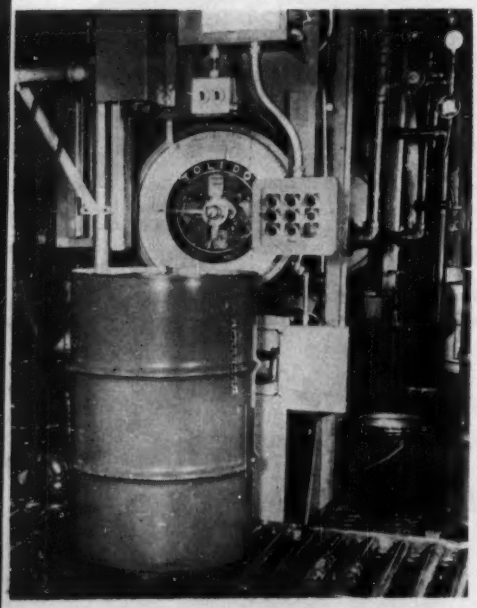
Facts-of-Life for successful engineers must include attitude, self-appraisal, vision, understanding, respect, relaxation and "happiness"

Achieving "success" and/or "happiness" in your professional and personal future won't just "happen," regardless of how diligently you apply yourself to your daily tasks, unless your efforts are coordinated along specific paths of endeavor. Your life as an engineer must be counterbalanced by your life as an individual — because "engineers ARE human," despite comment to the contrary.



AUTOMATIC drum filler keeps nozzle below surface of rising liquid, shuts itself off at preset weight.

either liquids or solids. The drum sits on a platform scale and is filled manually by an operator. When the scale indicator shows the right weight, the operator cuts off the flow, manhandles the drum out of the way and puts a new drum on the scale. This method is inaccurate and slow.

There is now automatic drum filling equipment that can be as fast and accurate as you want. One such type is an automatic drum filler for low viscosity liquids with foaming characteristics. The operator sets the unit for the desired net weight and an automatic tare device compensates for the weight of the empty drum. A filling ram lowers automatically into the drum and feeds the liquid with the nozzle always just beneath the rising surface to prevent foaming. Both fast and slow feeds give an accurate automatic cutoff.

Many dry materials can be fed into containers using similar cutoffs, with the user deciding on the practical balance between close accuracy and unusual speed at the time the equipment is specified.

▶Data Processing — Certainly one of the most dramatic areas of progress in weighing in recent years has been the development of means whereby scales can in effect read themselves. Now you can transmit weight data to almost any remote location in the form most suitable for the purpose, making the recording of weights as automatic as the weight indication itself.

Data resulting from an automatic operation can be fed into any of many types of office machines, or stored on punched tape or cards for subsequent processing.

The logging typewriter offers important advantages too, particularly in establishing a record of ingredients going into batches. An excellent record can be produced with this equipment on forms with identified columns. A ready-mix concrete operator, for example, uses a typewriter log record to certify to his customers the ingredient weights and the batch weight.

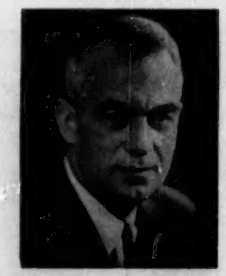
When records are to be stored for later processing there are several types of recording units that can receive weights transmitted automatically from remote locations. One of these is, of course, the tape punch. Where both a tape record and an adding machine strip are desired, a printer-punch can be the recording unit.

If additional identifying data is required, you can get a manual data input station that permits lot numbers, grade information, etc., to be inserted in the printed record for accounting.

▶Weighing for Cost Control— Most manufacturing operations can be described in terms of materials being received, processed, perhaps warehoused, and then shipped. Weighing is linked directly to these four steps as a dependable measure of cost control. As a result, it is a basic ingredient of the accounting routine through which receivables are paid, inventories valued and customers invoiced on the basis of weight records.

What principles can be applied in the effective selection of weighing equipment? This is not an easy question when the great amount of available equipment is considered. Let's assume that you are thinking in terms of an existing plant. Obviously, accuracy is a prime consideration. Equally important, however, is the question of adequacy for your present needs. A common discovery is that older scales bought for high capacity use are now used for weighing expensive materials in smaller quantities. Can the existing scale produce the kind of printed records demanded by accounting? Is the weighing a manual operation with high chance for human error that could be eliminated with fully automatic equipment?

Questions such as the above come up when a review is made of weighing in your plant. You can answer many of them from your thorough knowledge of your requirements. Your answer to a given problem may be a scale providing only automatic indications, or it may be a multiple unit system interlocked through automatic controls, or it may be a custom unit built for your specialized needs. The careful study that goes into the right choice is worth it in the high degree of control now obtainable with a modern weighing system. There is no substitute for the right scales in the right spots as components of a modern weighing system to guard quantity and quality.



RICHARD Y. MOSS is a graduate of Purdue University from which he obtained his bachelor's degree in Chemical Engineering. Prior to his association with Toledo Scale, he served in executive capacities at Lukens Steel Co., E. W. Bliss Co. and the Sheffield Div. of Bendix Corp.

Mr. Moss is now vice president and a director of Toledo Scale Corp. and general manager of its Toledo Scale Div.

Nickel flash tank starts 11th year in 50% hot caustic service

Ever since 1950, this Nickel flash tank has been in constant service concentrating dilute caustic soda to 50% strength. Temperatures range from 225° to 290°F. The tank is used by the Penobscot Chemical Fibre Company*, manufacturers of high-quality woodpulp.

How is the tank standing up? It's still as good as new. Many, many more years of service are expected from it.

What about maintenance? Practically none!

Corrosion tests, too, point to Nickel

Tests conducted in evaporators concentrating caustic soda up to 50% show that Nickel is the practical solution to corrosion problems. The corrosion rate of Nickel proved to be only 0.0001 ipy. This performance was then confirmed by analysis of the caustic soda for Nickel content...

The caustic soda contained a Nickel content of just 0.00005%!

Nickel evaporators are now in service concentrating caustic soda to about 75%. Rates of corrosion are slightly higher at this concentration, but available data indicate that under normal conditions the rate of corrosion is usually under 0.003 ipy, or only about 1/100 the rate of corrosion of steel.

Tests in Caustic Soda Being Concentrated From 60 to 75 Per Cent

Temperature: 149° to 177°C (300° to 350°F)

Material	Corrosion Rate mdd	ipy
Nickel	6.5	0.0010
Monel alloy	29	0.0047
Copper-Nickel (70-30)	34	0.0055
Copper-Nickel (80-20)	38	0.0062
Arsenical Copper (0.43% As)	254	0.041
Nickel-Chromium Steel (15-11)	55	0.010
Chromium-Nickel Steel (18-9)	400	0.073

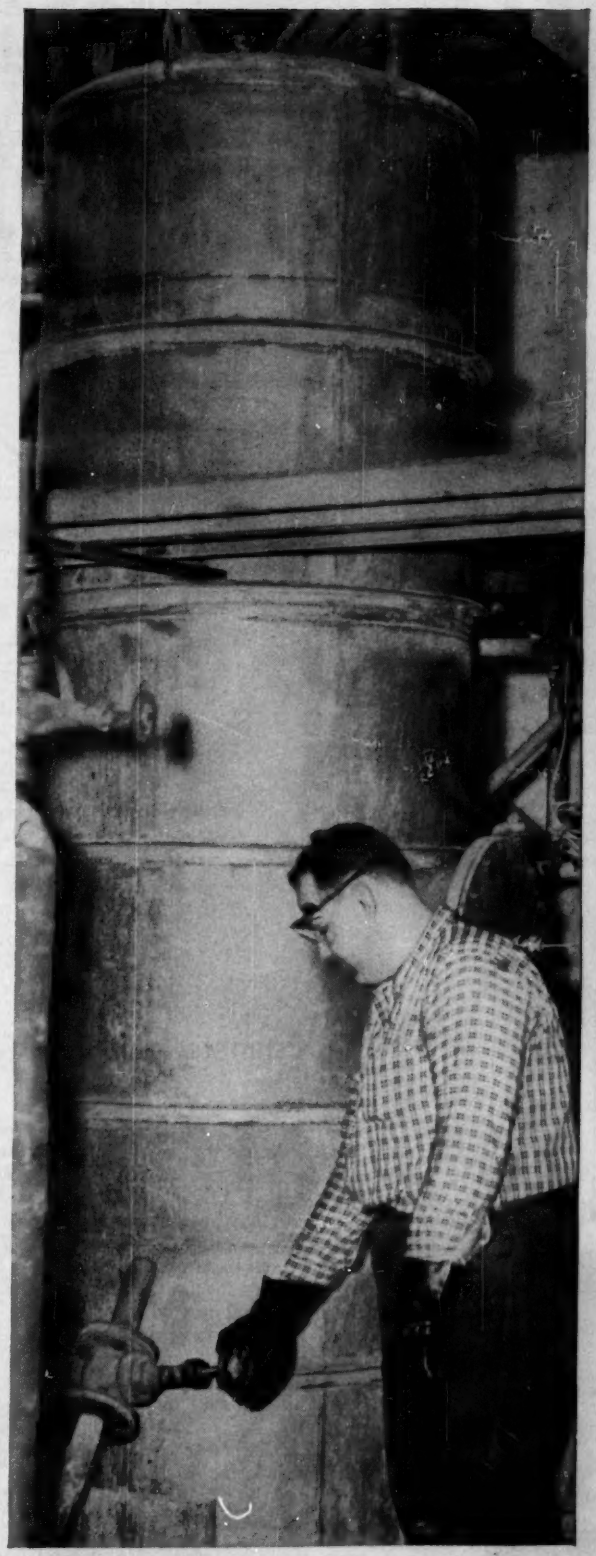
Specify Nickel

If you're faced with a caustic handling problem you'll find a ready-made answer in Nickel. You'll find the right corrosion-resisting properties. You'll find the mill form you need — available off the shelf. You'll find, too, Nickel fabricates easily. Welds readily. Offers important manufacturing economies.

Remember too, we'll be glad to give you any help you need in selecting the right material to solve your corrosion problems. Just write to:

*Old Town, Maine plant.

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

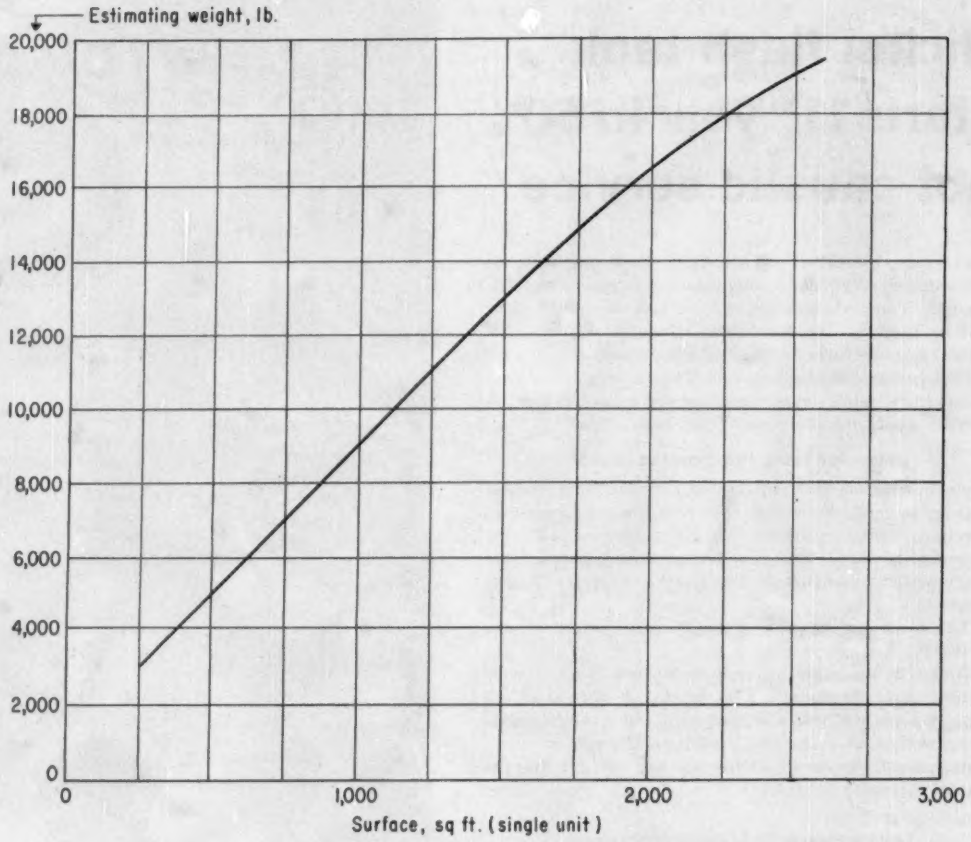


NICKEL

CE COST FILE

No. 37: Labor Factors; Heat Exchangers

Donald F. Brosnan, New York, N. Y.



Estimate Installation Costs for Heat Exchangers

CE Cost File has published data on costs of purchase for heat exchangers (*Chem. Eng.*, Aug. 11, '58, p. 151; Oct. 6, '58, p. 141; Nov. 17, '58, p. 166; Dec. 1, '58, pp. 123-4; Dec. 15, '58, p. 181; Dec. 29, '58, p. 63; Jan. 26, '59, p. 116). Labor factor data contained in this Cost File are intended to be used in conjunction with these material cost data.

Factors involved in installation of a heat exchanger are weight and size of exchanger and height at which it is installed. Since often the weight of the exchanger is unknown, the graph shown, correlating weight vs. single unit heat transfer area, conveniently summarizes this informaton.

Note that the graph purposely neglects effects of sheil thickness and tube material and thickness because they affect installation cost only slightly. After determining weight from the chart, you can determine grade-level erection man-hours from the following tabulation:

Weight	Erection Man-Hours
≦4,000 lb.	35
4,000-10,000 lb.	60
≧10,000 lb.	60+1 man-hr./1,000 lb. over 10,000 lb.

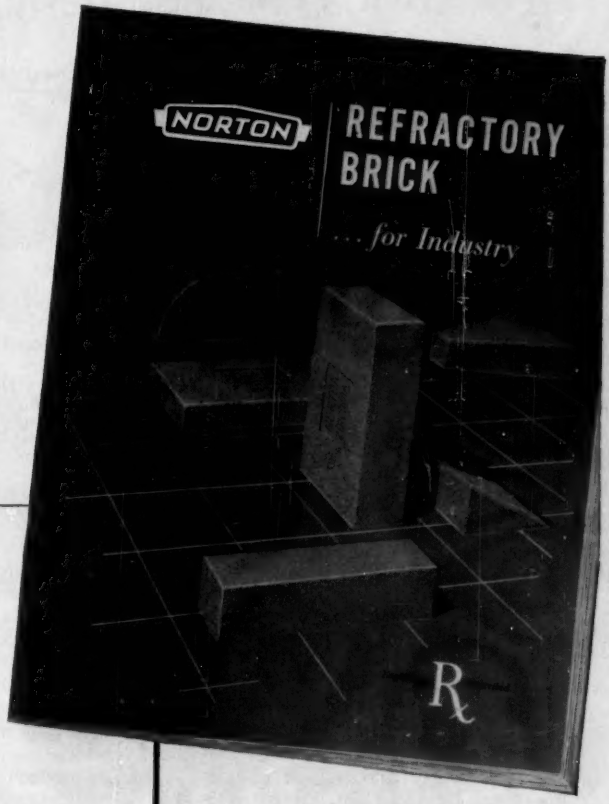
Because of additional rigging and handling in installation of exchangers in elevated structures, the following height factors should be added to the grade-level erection man-hr. given above:

Height	Additional Man-Hr., %
0-20 ft.	0
20-40	10
40 and greater	15

Labor rate to be used with the above labor factors is either that of pipefitters or of boilermakers, depending on which craft applies in a particular location.

Send for this

New Booklet to Help Improve Your High Temperature Processing



Covers Norton refractory brick applications, characteristics, chemical analyses — includes helpful data on materials of construction for temperatures up to 4,400°F.

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Eight Norton-developed refractory materials are covered: ALUNDUM* "T" 87% Alumina; ALUNDUM "A" 99% Alumina; ALUNDUM "L" 99% Insulating Alumina; CRYSTOLON* "G" Silicon Carbide; CRYSTOLON "N" Nitride Bonded Silicon Carbide; MAGNORITE* "K" Fused Magnesia; Zirconia "H" Dense Zirconia; Zirconia "I" Insulating Zirconia.

All essential details are listed, such as: how each material is produced . . . important properties, characteristics and chemical analyses . . . shapes of brick and other molded products that are available . . . representative applications . . . packing methods that assure safe arrival.

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PRACTICE . . .

CORROSION FORUM

EDITED BY R. B. NORDEN

CORROSION-CONTROL DESIGN 5b

Part of a series appearing throughout 1960

Design Tips Reduce Tank Failures

Uncomplicated interiors, all-welded construction, complete drainage, flush flange gaskets are important points to consider in minimizing storage-tank corrosion.

C. K. ALDRICH, Consulting Engineer, Buttzville, N. J.*

The guiding principle for designing storage tanks handling corrosive fluids can be stated simply: keep the exposed, internal metal surface to a minimum.

In practice, this "guide" is definitely not easy to follow. But any steps in that direction will pay dividends. We have covered some of the over-all design factors in our first article (*Chem. Eng.*, July 25, 1960, p. 148). Now we will concentrate on tank internals. For instance, whenever possible, eliminate inside piping, baffles and ladders. Keep reinforcing or supporting members outside the vessel to reduce the internal surface.

▶**Crevice Corrosion** — One major problem with storage tanks involves crevice corrosion (formation of differential aeration or solution-concentration cells). It is a good idea to design vessels with a minimum number of crevices—another aspect of the exposed-surface problem.

Riveted construction results in a great number of crevices between overlapping plates. Therefore, welded tanks are much preferred.

If they can't be avoided, internal piping such as heating coils must be held away from the vessel wall by suitable supports or hangers (see *Chem. Eng.*, May 16, 1960, p. 172). Install these supports so no crevice exists between them and the vessel wall. Welding all around usually solves the problem. This same idea also applies to baffles.

Many corrosion problems have developed at the point where piping enters a vessel. In such cases piping may go through an external packing gland or be externally welded to the vessel wall. Either procedure will leave a crevice around the pipe on the inside of the tank, acting as a focal point for corrosion. It is better practice to place the weld on the inside. If this isn't possible, or if packing glands are used, the crevice needs caulking with some resistant material.

Finally, flanged connections and gaskets must not have recesses between the flange faces where corrosion products will accumulate or where liquid will be trapped when the system is emptied.

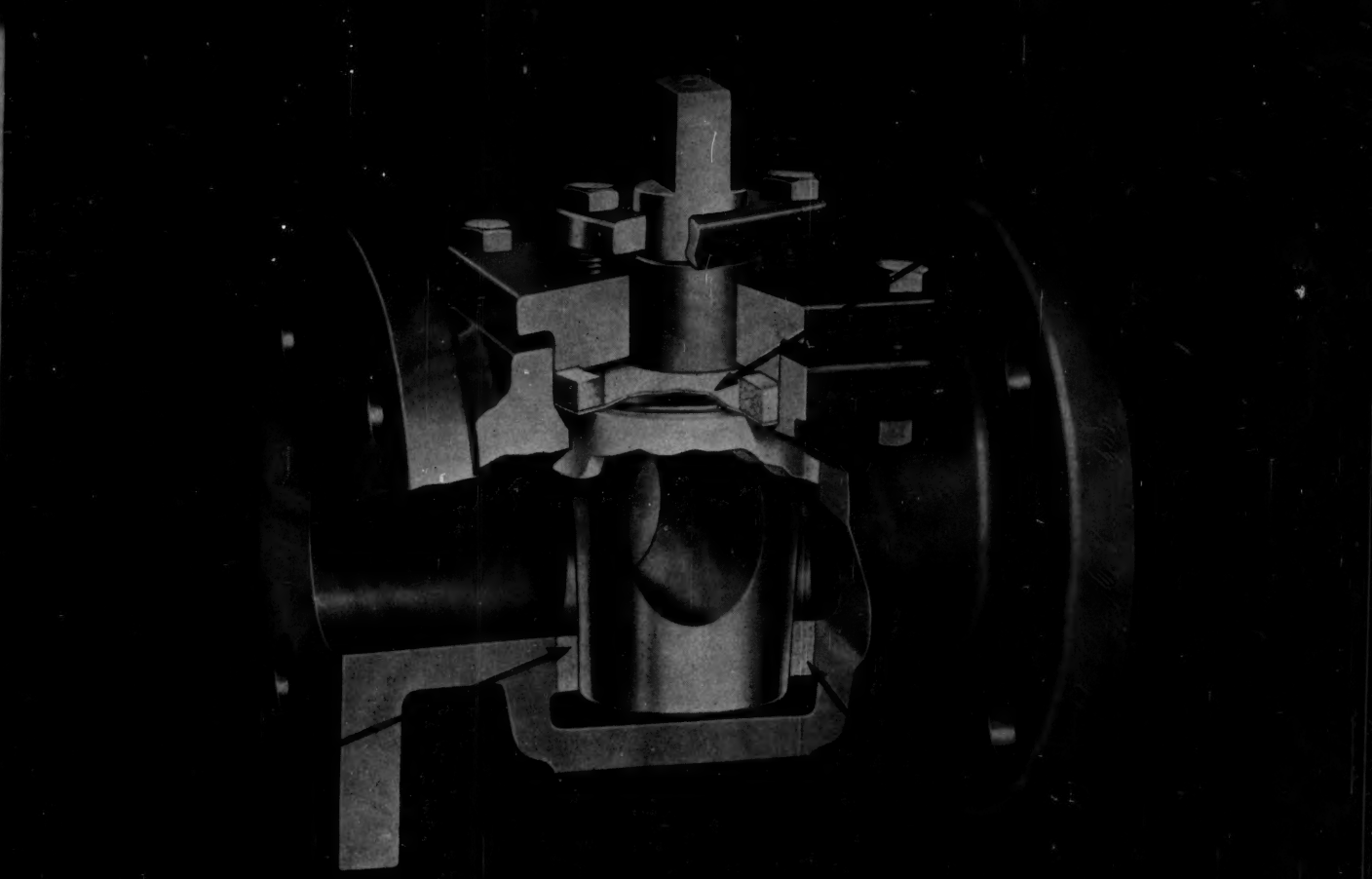
▶**Proper Drainage** — Tanks which are emptied periodically and remain empty for extended periods, call for complete drainage. Any internal feature such as a weld bead around the bot-

*For author biography, see *Chem. Eng.*, July 25, p. 152.

1. Plant Site, Layout Minimize Corrosion, Jan. 11, 1960, p. 144.
2. Proper Design Voids Equipment Corrosion, Feb. 22, 1960, p. 162.
3a. Often Overlooked Reactor Design Factors, May 2, 1960, p. 150.
3b. Keys to Corrosion-Wise Reactor Design, May 16, 1960, p. 170.
4a. Valve Design: Special for Corrosives, June 13, 1960, p. 238.
4b. Valves for Severe Corrosive Service, June 27, 1960, p. 146.
5a. How to Extend Storage-Tank Life, July 25, 1960, p. 148.

. . . . . Future Articles

Design of heat exchangers to minimize corrosion.
Design of mixers to minimize corrosion.



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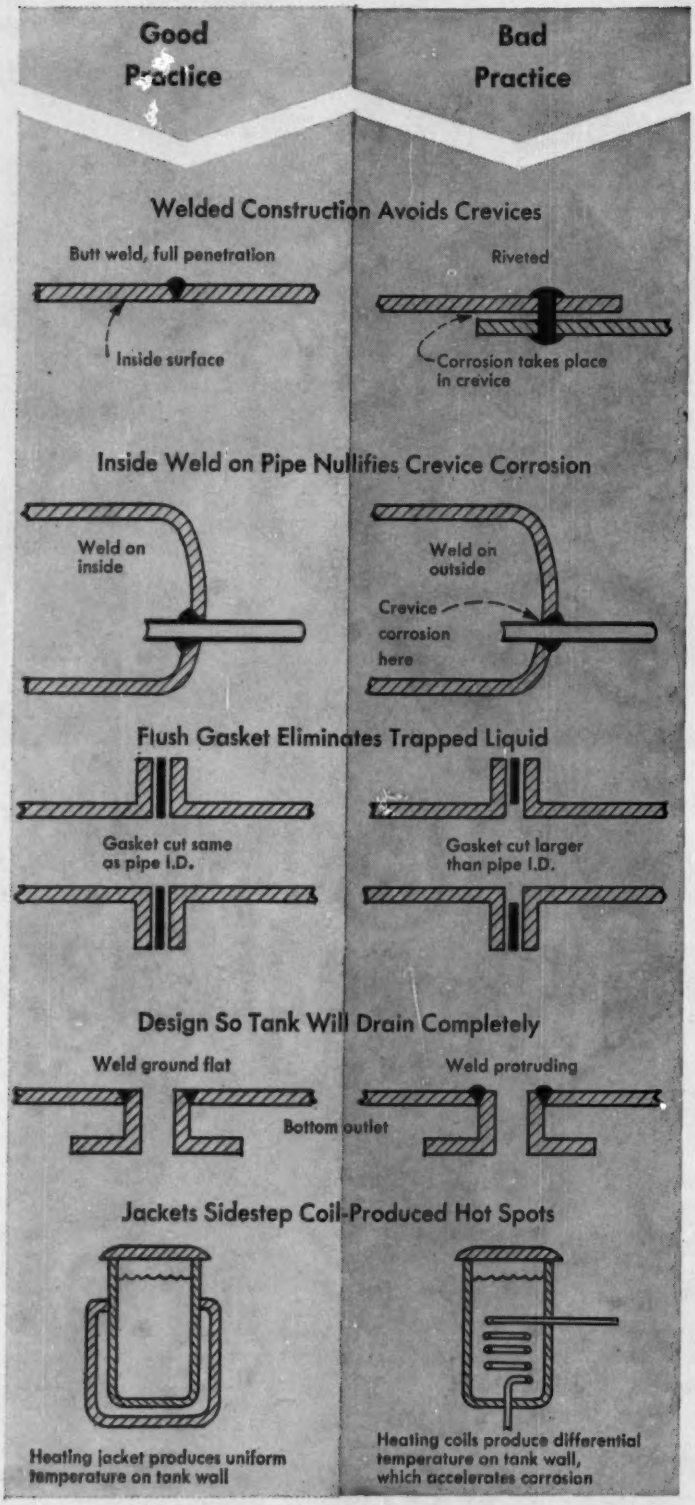
Fewer Tank Headaches Via Proper Design


Good Practice
Bad Practice
Welded Construction Avoids Crevices
Butt weld, full penetration
Inside surface
Riveted
Corrosion takes place in crevice
Inside Weld on Pipe Nullifies Crevice Corrosion
Weld on inside
Weld on outside
Crevice corrosion here
Flush Gasket Eliminates Trapped Liquid
Gasket cut same as pipe I.D.
Gasket cut larger than pipe I.D.
Design So Tank Will Drain Completely
Weld ground flat
Bottom outlet
Weld protruding
Jackets Sidestep Coil-Produced Hot Spots
Heating jacket produces uniform temperature on tank wall
Heating coils produce differential temperature on tank wall, which accelerates corrosion

tom-outlet nozzle, heating-coil supports or baffles, which will hold back a heel of liquid, must be eliminated. Concentration of solution through evaporation at such locations can result in accelerated corrosion.

▶**Avoid Heating Coils**—When storage tanks are to be heated, some consideration has to be given to the heating method.

Temperature differences on a metal surface can accelerate corrosion—the heated area will be anodic to the cooler area. Therefore, externally welded-on coils result in hot spots on the tank wall adjacent to the coils—not a good situation from a corrosion standpoint. In addition, external heating coils cause local stresses in the tank wall. Although not always practical for large tanks, heating jackets, which uniformly heat a surface, are much preferred.

▶**Lined Vessels**—For many environments it is economical to use a low-cost metallic material of construction and provide a corrosion-resistant lining. Such tanks should be specifically designed for lining.

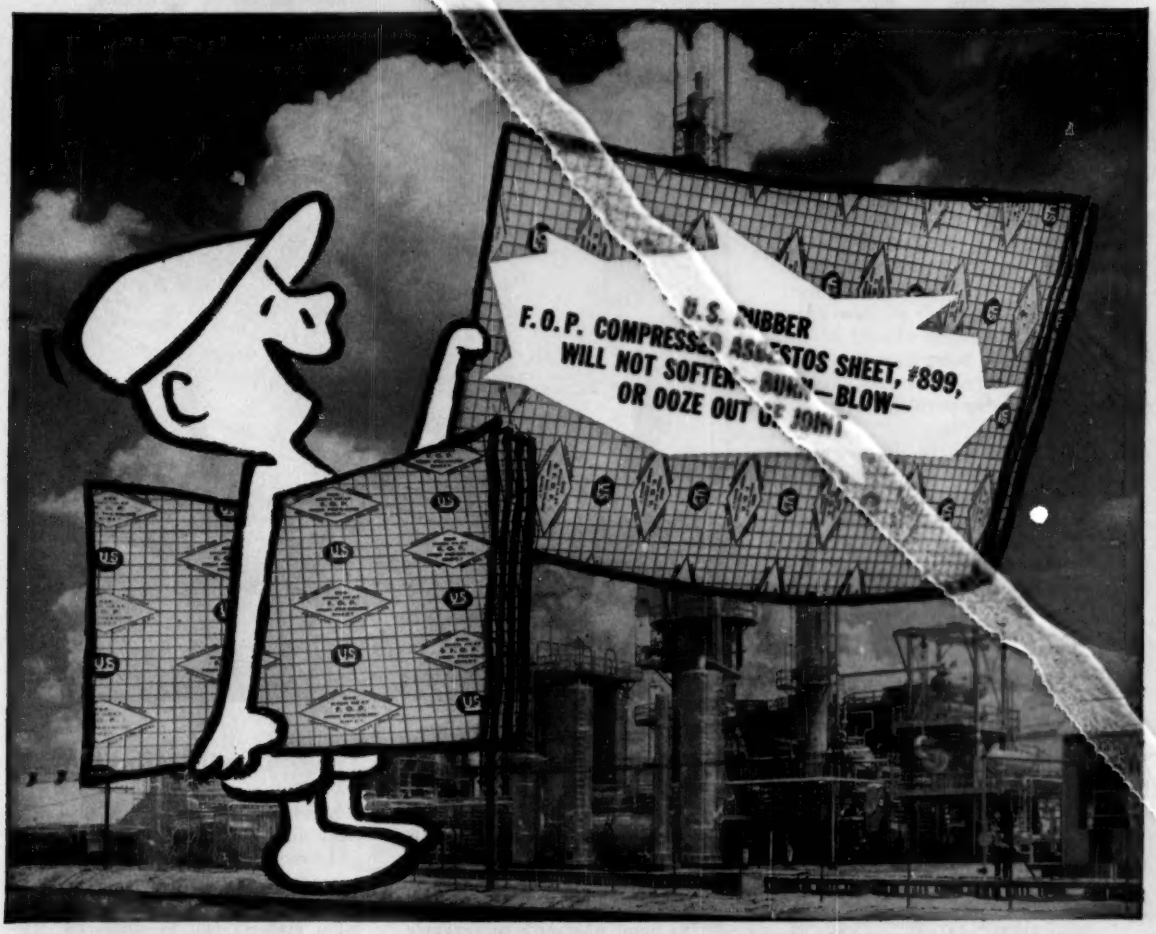
In general, the interior surface must be as uncomplicated as possible. All sharp edges have to be rounded off by grinding. Grind weld beads flat and provide fillet welds in sharp corners. There must be no crevices which will contain moisture or corrosion products. And the entire surface must be accessible for application of the lining. The lining must be continuous over the entire surface and all openings or nozzles flanged so the lining can be carried intact over the face of the flange.

Reliable applicators will insist on these points and are often set up to see that they are fulfilled. However, where lining jobs are attempted by relatively inexperienced plant-maintenance personnel, serious troubles often develop.

This is illustrated by early failure of a sheet-lead lining applied by plant-maintenance people. The lead was applied to a welded steel vessel and during dressing operations the thickness of the lead sheet was reduced by about one-half over weld beads. In a relatively short time cracks developed in these

US RUBBER PACKING

HOT NEWS for Hot Joints and Flanges



This is the packing that's making headlines where the going's the hottest . . . where flanges or joints must be packed against superheated or saturated steam, air, water, ammonia, gases, oil, gasoline and many chemicals.

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weakened areas and it was necessary to remove portions of the lining, grind down the weld beads and then burn in lead patches.

▶**Blisters From Hydrogen**—Another factor which may be overlooked in lining steel vessels is the possibility of absorbed hydrogen. Any vessel which has been in service—and new construction, if the steel has been through a pickling operation—may contain hydrogen. Subsequent heating even slightly above ambient temperature will force this hydrogen out of the metal, resulting in blistering and loss of adhesion of the lining.

Where such a possibility exists, the vessel should be preheated to a temperature at least 50° above the maximum expected operating temperature before applying the lining.

In cases where linings are to be field applied take special precautions to see that the desired preheat temperature is reached. This was forcefully demonstrated in the case of a large, vertical, cylindrical steel-storage tank, resting on a concrete pad, which received a baked-phenolic lining in the field.

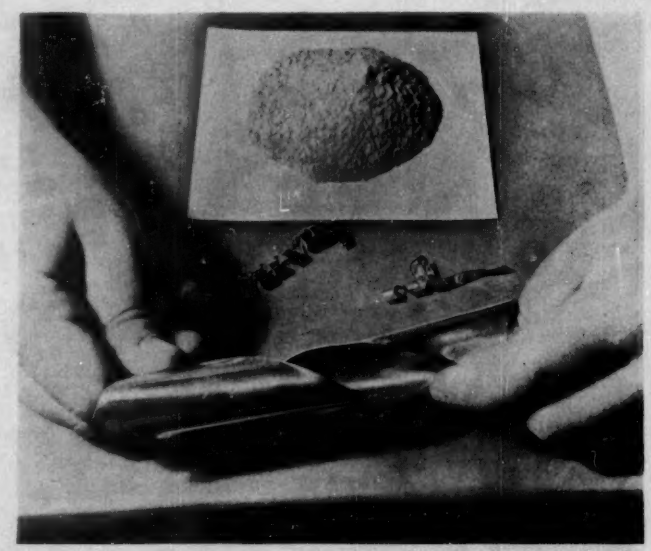
The tank had been exposed to an environment which caused hydrogen embrittlement so the possibility of absorbed hydrogen in the steel was apparent to everyone concerned. The applicator preheated the tank, with forced hot air, above the baking temperature. This temperature was checked with thermocouples located at strategic points within the tank. The record showed these temperatures were well above that required for baking.

When the lining was applied and baked, however, blisters developed in the bottom portion. It became apparent that the bottom plates, resting on a cold concrete pad, did not reach the indicated temperature. This resulted in an argument between the applicator and the purchaser concerning the adequacy of the preheat, which could have been prevented if a more positive method of indicating temperature had been employed. The use of temperature-indicating crayons, which indicate actual metal temperature would have precluded any argument.

Finally, any lining specification should require a dielectric or other leak test. For liquid-applied organic coatings, minimum thickness must also be spelled out for the applicator.

REFERENCES

1. Collins, J. A., *Corrosion*, **11**, 11t (1955).
2. Jelinek, R. V., *Chem. Eng.*, Nov. 1958, p. 151.



Novel Powder Metallurgy Yields Ductile Alloys

Alloying aluminum with boron carbide or rare-earth oxides—very useful combinations for controlling nuclear reactions—usually embrittles aluminum to the point where it's unworkable. This is all changed with development of a novel powder-metallurgy technique. Aluminum-boron alloys are available now with about the same ductility as pure aluminum.

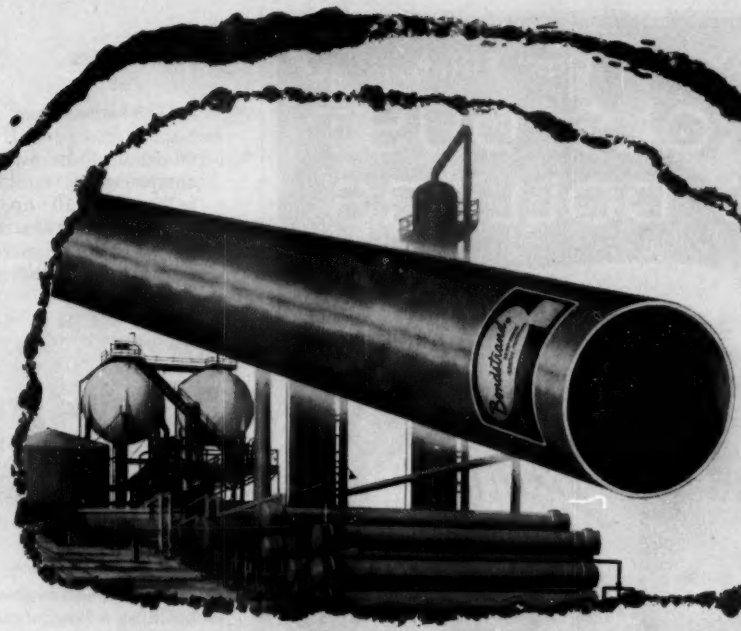
According to the developer, Sintercast Div. of Chromalloy Corp. (Yonkers, N. Y.), the product has physical properties equal to or better than a cast or wrought alloy of the same composition.

But in addition, the sintered product is more uniform, purer and can be held to closer composition tolerances than an alloy made by melting and casting—important considerations in nuclear work.

A boron-containing alloy (boron carbide, with an affinity for neutrons, dispersed in an aluminum matrix) can be produced as strip, foil, plate, tubes, or fabricated into a number of complicated parts.

Process is applicable to compositions containing up to 30% (by volume) of dispersoid—usually an oxide, carbide, boride. And it's not limited to aluminum. Ductile, sintered compositions of rare earths and stainless steel have been made.

Technique involves compacting powder, sintering at a temperature below the melting point, then hot-working to eliminate porosity. This last step is a key point in making a ductile product.



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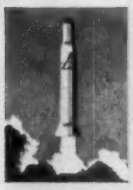

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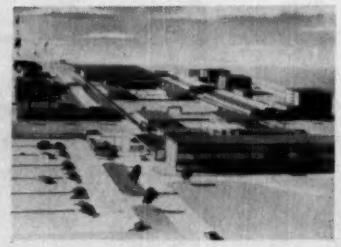
EQUIPMENT SYSTEMS INSTALLATION

(*Continued from p.* 70)

66 mi. of 30-in. pipeline loops, compression equipment totalling 33,710 hp. for four existing compressor stations, and auxiliary metering and regulating facilities.



Texaco Inc. announces that it is building a large new petroleum research center. Location is Port Arthur, Tex., where the company's largest domestic refinery is also situated. Construction will cost over $7.5 million and will require five years. A model of the center is shown above. Immediate purpose of the new project will be to provide centralized and improved facilities for scientists and engineers who now work at separate locations throughout the Port Arthur refinery. The facility will be Texaco's second major petroleum research center.

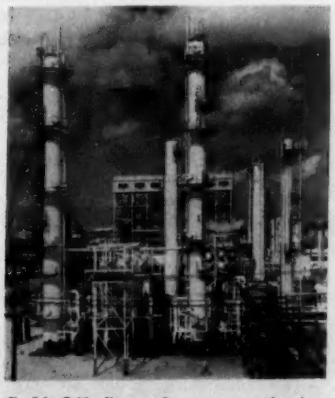
Hooker Chemical Corp. will build a new plant to produce synthetic phenol. The multimillion-dollar venture will be located on the Ohio River near South Shore, Ky., and operated by the firm's Durez Plastics Div. Construction will start later this year, and the company expects that it will be completed by the end of 1961. Plant will use the new Hooker phenol process, which is the result of research and development efforts on the Raschig process that Durez currently uses at its North Tonawanda, N. Y., plant.

Du Pont will increase production of nylon cord from 40 million to 100 million lb./yr. at its Richmond, Va., plant. The expansion will require a multimillion-dollar outlay, and the company expects to start con-

struction immediately. The expanded plant will use a new manufacturing process which yields a superior nylon yarn.

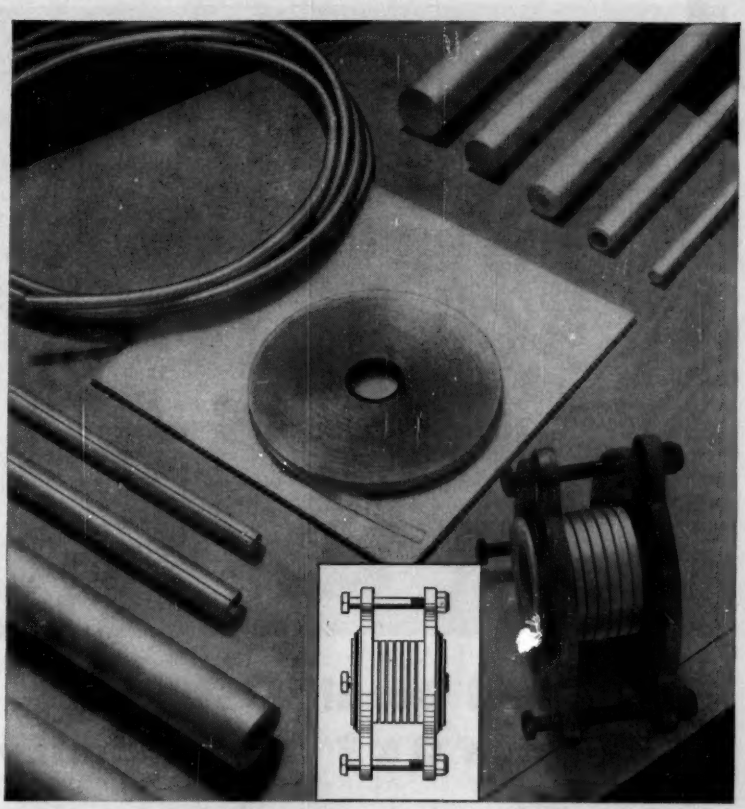
Republic Steel Corp. is starting on a $26-million improvement program for its plant at Cleveland. The following projects are included in the program: modernization of benzene refining equipment, replacement of some coal preparation facilities, modernization of a 10-in. bar mill, and improvement of material-handling facilities for an open hearth shop.

H. K. Porter Co., Inc., announces the start of a $4-million construction and equipment modernization program for two plants in its Refractories Div. Major feature will be installation of two new tunnel kilns for a plant at Wellsville, Ohio, and one new tunnel kiln for the division's Bessemer, Ala., plant. Also included in the program are new dryers for both plants.



Gulf Oil Corp. has recently installed at its Port Arthur, Tex., refinery the new propylene polymer fractionating towers pictured in the foreground above. Gulf uses one of the tower products for manufacture of decyl alcohol; the other products from the towers are sold to customers, primarily for conversion to detergents.

Sherwin-Williams Co. will build a multi-million-dollar paint factory and wholesale distribution center near Atlanta.



For resistance to practically everything, specify R/M "Teflon" gasketing and other parts. The complete R/M "Teflon" line includes expansion joints (lower right corner of this illustration), color-coded thin-wall tubing, bondable "Teflon" sheets, etc.

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No need to restate the unique combination of properties that sets "Teflon" apart. You *know* that for certain process-equipment parts nothing else will do.

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It will pay you to talk "Teflon" with R/M. Call your nearest R/M district office (listed below) or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

*Registered trademark for Du Pont fluorocarbon resin

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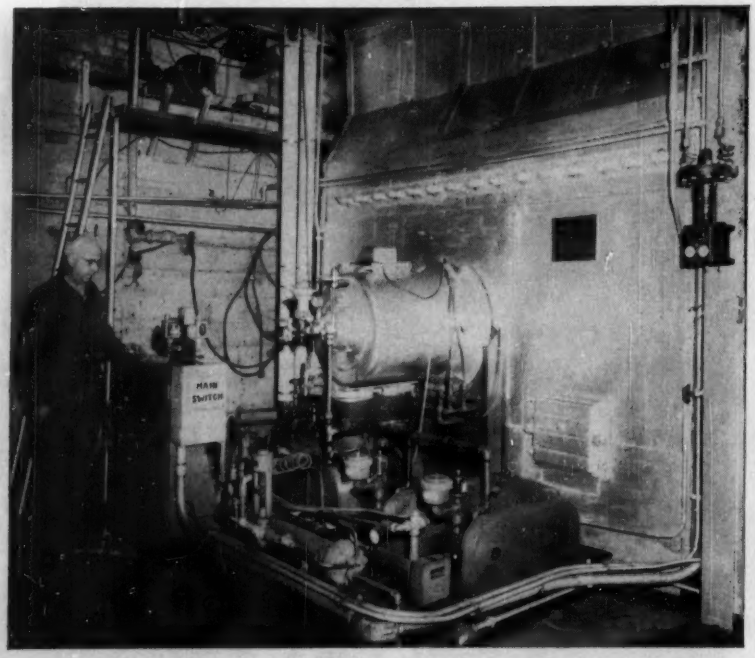

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Want more proof? We have an impressive array of case histories and performance data that are eye-openers. You owe it to yourself to investigate this outstanding burner system. Write for Bulletin 1255.

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Company is first building a warehouse containing 40,000 sq. ft.; manufacturing facilities will be erected in the near future.

Mitronics, Inc., has installed a large molybdenum-rod hydrogen furnace for firing metallized ceramics at its plant in Hillside, N. J. Shown above, the custom-built furnace is about 18 ft. long and has a 10 x 8-in. opening. It is heated by molybdenum rods and can operate at temperatures up to 3,200 F. The furnace was built by CM Mfg. & Machine Co., of Bloomfield, N. J. CM states that it is the largest hydrogen furnace ever built for ceramic industry use.

Suntide Refining Co., a subsidiary of Sunray Mid-Continent Oil Co., is planning to construct a hydrodealkylation (Hydeal) unit at its Corpus Christi, Tex., refinery. To cost over $1 million, it will produce benzene from toluene and is expected to go on stream early next year.

Haveg Industries, Inc., announces that its new Research and Development Laboratory in Taunton, Mass., has been completed. The new facility will be used for study of plastics, elastomers and ceramoplastics.

Lane Mountain Silica Co. is now constructing a $500,000 plant to produce high-quality silica sand at Valley, Wash. The plant, with an initial capacity of 400 tons/day, will provide the Pacific Northwest with its first major source of the high-quality material. A likely consumer of much of the plant's

output will be Northwestern Glass Co., located in Seattle, which owns 35% stock interest in the Lane Mountain firm.

Pennsalt Chemicals Corp. is building a new unit at its organic sulfur chemicals plant in Houston. It will produce a variety of alkyl mercaptans, and is expected to cost over $750,000. The unit is scheduled to be completed by early 1961.

Armco Steel Corp.'s Sheffield Division is installing facilities that will produce heat-treated, high-strength alloy steel plate at the division's Houston plant. These will reportedly be the first facilities of their kind in the Southwest, and Sheffield is installing them in the face of foreign steel imports to the area. The new equipment will be able to heat-treat plates up to 144 in. wide, 2 in. thick and 45 ft. long, at a maximum rate of 18 tons/hr. It will probably be in production by next spring.

Atomics International, division of North American Aviation, Inc., has developed the giant nuclear-fuel-handling cask seen above. It has been undergoing tests at the company's nuclear field laboratory near Los Angeles; next February it will be shipped to the Atomic Energy Commission's Hallam nuclear power facility in Nebraska. The machine, 54 ft. high, will handle and load re-

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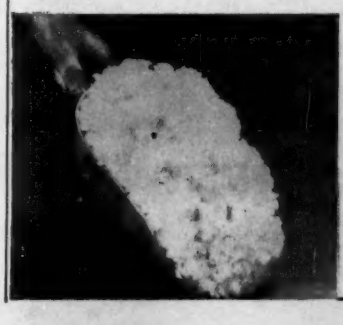

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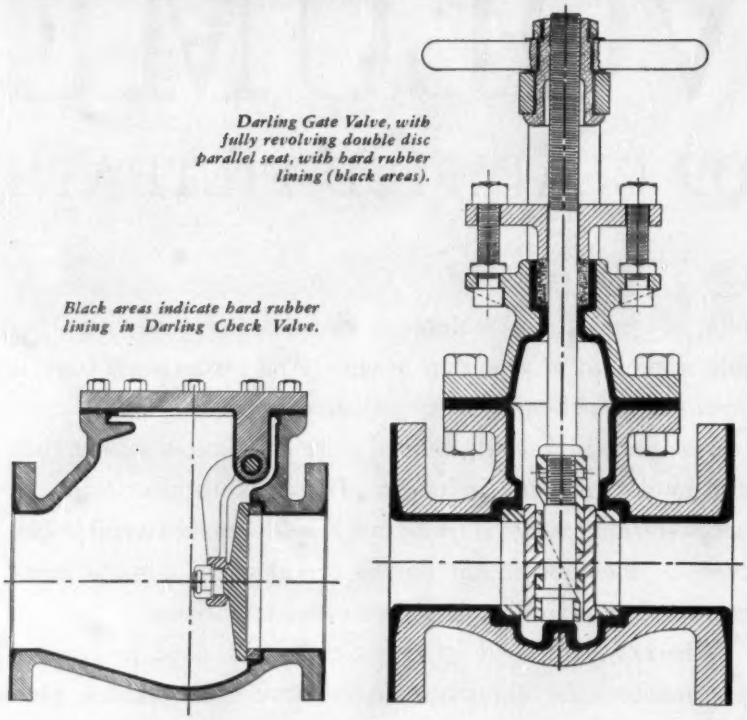
IRON BODY VALVES CAN WORK IN CORROSIVE SERVICE



Darling Gate Valve, with fully revolving double disc parallel seat, with hard rubber lining (black areas).

Black areas indicate hard rubber lining in Darling Check Valve.

Here's a way to make substantial savings in valves for corrosive or abrasive service. Darling Iron Body Check Valves and Gate Valves may be obtained with special hard rubber linings. This means you can often save the cost of expensive special alloy valves, yet obtain high resistance to corrosion or abrasion.

Darling Check Valves employ a streamlined body design especially selected for application of hard rubber lining. Excess area through the valve minimizes abrasion and insures full delivery of line capacity.

Darling Rubber-Lined Gate Valves give you the advantages of the revolving double disc parallel seat and "no pocket" discs ... which provide positive sealing and assure ease of operation. Available in outside screw and yoke type, in sizes from 2 inches to 24 inches. Write for further information.

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actor components 40 ft. long for Hallam's sodium-graphite reactor, which is also being built by Atomics International.

Chemetron Corp.'s Chemical Products Div. has a new processing unit in full scale operation at a plant in Newport, Tenn. Unit manufactures sodium xylenesulfonate and sodium toluene-sulfonate.

Monsanto Chemical Co. has started up a new unit to produce high-quality dihydroxydiphenyl sulfone at the firm's plant in Monsanto, Ill. Product is used as an intermediate in tin plating and as an additive in manufacturing resins.

Dow Chemical Co. has announced plans for building the first portion of its forthcoming research center in California's Ygnacio Valley. Site will be near Concord, about 30 mi. east of San Francisco. The first portion will consist of a one-story building which will house eight chemists. A building to house about 100 people will be constructed later.

Goodyear Tire & Rubber Co. will spend more than $1 million for new processing equipment at its plant in Niagara Falls, N. Y. This expansion will add about 20 million lb. to the plant's annual vinyl resin capacity, and will double production of two specialty dispersion resins. The new equipment will be installed by early this fall.

Sun Oil Co. has formed a new wholly owned subsidiary named Sunoco Trading Corp. The new corporation will buy and sell crude oil and petroleum products world-wide.

Continental Oil Co. has purchased 25% interest in Carlon

Products Corp., reportedly the world's largest producer of plastic pipe. In announcing the purchase, a Conoco spokesman pointed out the increasing importance of plastic pipe in the oil and petrochemical industry. Carlon's headquarters and principal plant are at Aurora, Ohio.

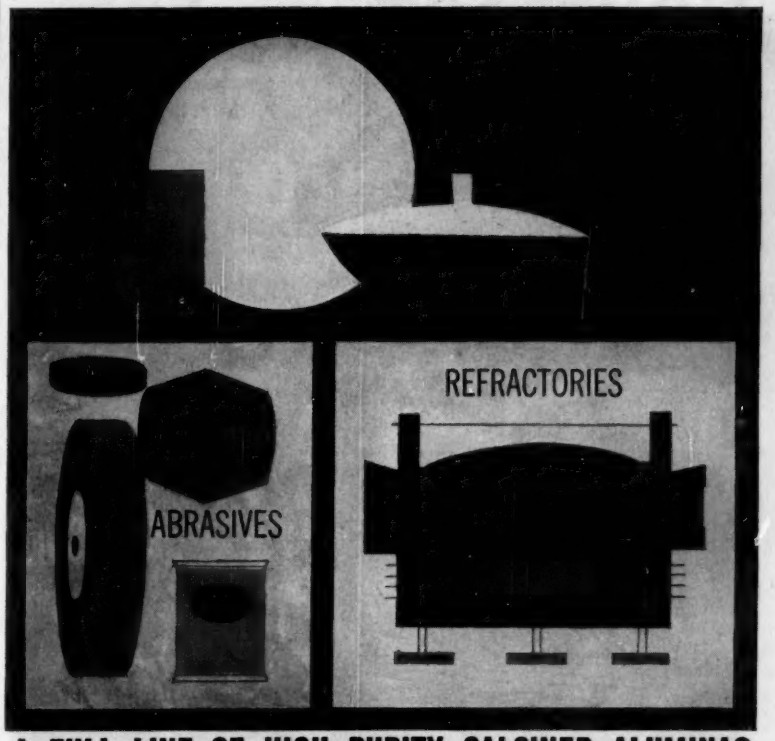
Hexcel Products Inc., a Berkeley, Calif., manufacturer of honeycomb materials (such as cores for aircraft) has purchased the assets of Applied Plastics Co., Inc. Latter firm is a producer of resinous products at El Segundo, Calif., and includes adhesives, coatings, foams and hardening systems for epoxy resins on its product list.

Texaco Experiment Inc. is the new name for the Texaco subsidiary that was previously known as Experiment Inc. The firm, located in Richmond, Va., became wholly owned by Texaco on June 1, 1959. It carries out research on combustion processes and development of propulsion systems for missiles and space vehicles.

OVERSEAS BRIEFS

Scotland: British Hydrocarbon Chemicals Ltd. is adding a butadiene extraction plant, a methanol unit and an ethylene dichloride plant to its facilities at Grangemouth. The three units are scheduled for completion next year.

Union of South Africa is soon to have a new nuclear research and test reactor. Under a recent agreement reached by the South African Atomic Energy Board, the Roberts Construction Co. of South Africa and Allis-Chalmers nuclear power department, Allis-Chalmers will act as a nuclear subcontractor to Roberts Construc-



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Fe_2O_3	0.02	0.02	0.02	0.02
TiO_2	0.002	0.002	0.002	0.002
Na_2O	0.60	0.50	0.10	0.04
Loss on ignition	0.70	0.10	0.15	0.15
Al_2O_3 (by difference)	98.65	99.36	99.50	99.60

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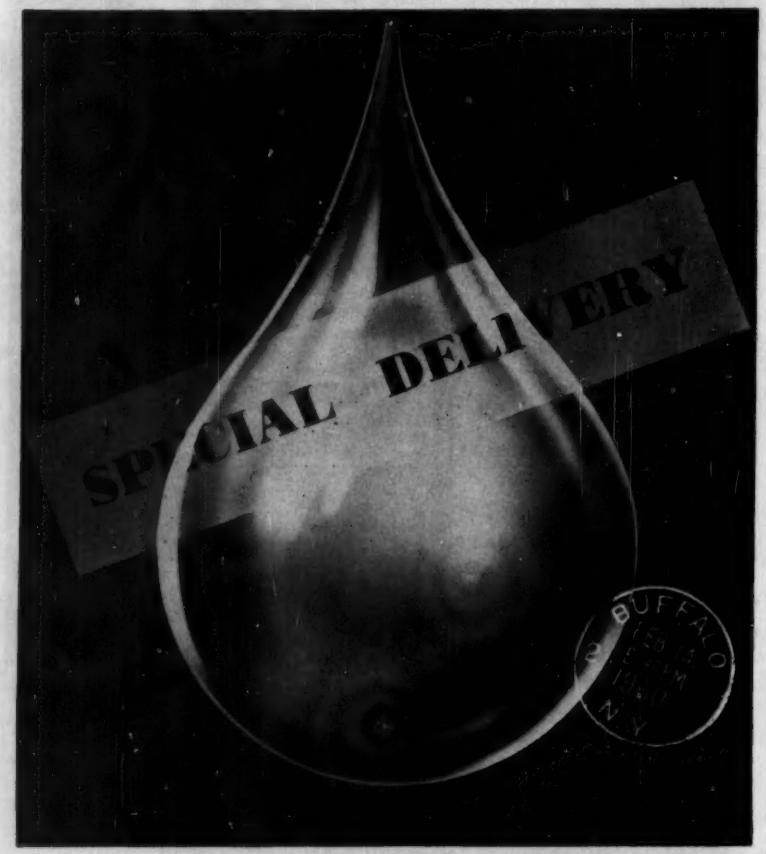

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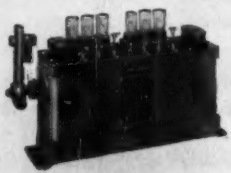

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tion and will design and build the reactor. It will be an advanced version of the ORR reactor now operating at the U. S. Atomic Energy Commission's Oak Ridge Laboratory. Initially it will operate at a 6,600-kw. power level, but will be designed for ultimate operation at levels as high as 20,000 kw.

Virgin Islands: A 275,000-gal./day seawater conversion plant will be built at St. Thomas. It will produce fresh water by flash evaporation in 28 stages. Plant will be built by Cleaver Brooks Special Products; it is scheduled for delivery in February, 1961. The new unit is expected to reduce water costs by nearly 75%, because the St. Thomas area currently imports its fresh water by barge from Puerto Rico.

England: A new chemicals plant will be built at the Fawley refinery of Esso Petroleum Co., Ltd. An extension of Esso's present chemicals facilities at Fawley, it will feature a steam cracker and plants for ethylene recovery and butadiene extraction. It is part of an expansion program previously announced for the Fawley refinery, which is scheduled to be completed late in 1961. Detailed engineering and erection of the chemicals plant will be handled by Foster Wheeler, Ltd.

India: A plant to make furnace carbon black will be constructed near Durgapur by Phillips Carbon Black Ltd., a company formed jointly by Phillips Petroleum Co., of Bartlesville, Okla., and Duncan Brothers & Co., Ltd., of Calcutta. The plant is scheduled to be on stream within 17 months. It will have an initial design capacity of 22 million lb./yr., will use the basic process for carbon black which has been pioneered by Phillips. Feedstock will be coal tar distillates.

Northern Ireland: Chemstrand Corp.'s plant for production of Acrilan acrylic fiber at Coleraine is now in full operation.

CALENDAR

Gordon Research Conference, Organic Coatings, New Hampton School.
Aug. 8-12 New Hampton, N. H.

Technical Assn. of the Pulp and Paper Industry, 9th Pulp and Paper Statistics Course, Brevard College.
Aug. 8-19 Brevard, N. C.

American Institute of Chemical Engineers & American Society of Mechanical Engineers, National Heat Transfer Conference and Exhibit, Statler Hotel.
Aug. 14-17 Buffalo, N. Y.

American Society of Mechanical Engineers, Heat Transistor Division Conference, Statler-Hilton Hotel.
Aug. 15-17 Buffalo, N. Y.

National Bureau of Standards, Cryogenic Engineers Conference.
Aug. 17-19 Boulder, Col.

Technical Association of the Pulp and Paper Industry, 14th Alkaline Pulping Conference, Multnomah Hotel.
Aug. 22-24 Portland, Ore.

University of Colorado, 1960 Cryogenic Engineering Conference.
Aug. 23-25 Boulder, Col.

Association For Computing Machinery, National Meeting, Marquette University.
Aug. 23-25 Milwaukee Wisc.

Technical Association of The Pulp and Paper Industry, Forest Biology Conference.
Aug. 24-27 Seattle, Wash.

The Combustion Institute, 8th International Symposium, California Institute of Technology.
Aug. 28-Sept. 2 Pasadena, Calif.

Public Health Service, Water Quality Measurement and Instrumentation Symposium, Sanitary Engineering Center.
Aug. 29-31 Cincinnati, Ohio

Air Force Office of Scientific Research, 8th International Combustion Symposium.
Aug. 29-Sept. 2 Los Angeles, Calif.

Chemical Institute of Canada, Nuclear and Radio-Chemistry Symposium, Chalk River Laboratories.
Sept. 6-8 Chalk River, Ontario

Production Engineering Show, Navy Pier.
Sept. 6-16 Chicago, Ill.

Machine Tool Show, International Amphitheatre.
Sept. 6-16 Chicago, Ill.

Massachusetts Institute of Technology, Joint Automatic Control Conference.
Sept. 7-9 Cambridge, Mass.

American Chemical Society, National Meeting.
Sept. 11-16 New York, N. Y.

International Electrostatics Conference, University of Grenoble.
Sept. 27-Oct. 1 Grenoble, France

New Stokes size 1 Tornado Mill...

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extra heavy duty • rugged construction • portability

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CALENDAR . . .

American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Jung Hotel.
Sept. 26-28 New Orleans, La.

Instrument Society of America, Instrument-Automation Conference and Exhibit Coliseum.
Sept. 26-30 New York, N. Y.

National Association of Corrosion Engineers, six regional conferences.
West, Sheraton-Palace Hotel
Oct. 6-7 San Francisco, Calif.
Southeast, Dinkler-Plaza Hotel
Oct. 6-8 Atlanta, Ga.
Northeast, Prichard Hotel
Oct. 11-14 Huntington, W. Va.
North Central, Pfister Hotel
Oct. 19-20 Milwaukee, Wis.
South Central, Mayo Hotel
Oct. 25-27 Tulsa, Okla.
Canadian (Eastern), Sheraton Mount Royal Hotel
Nov. 14-16 Montreal, Quebec.

American Association of Textile Chemists and Colorists, 1960 National Convention, Sheraton Hotel.
Oct. 6-8 Philadelphia, Pa.

The American Ceramic Society, Refractories Division Meeting, Bedford Springs Hotel.
Oct. 6-8 Bedford, Pa.

American Vacuum Society, 7th National Symposium, Cleveland-Sheraton Hotel.
Oct. 12-14 Cleveland, Ohio

Industrial Management Society, 9th annual Methods Improvement Contest, Conrad Hilton Hotel.
Oct. 12-14 Chicago, Ill.

American Society of Mechanical Engineers & American Society of Lubrication Engineers, 7th Annual Lubrication Conference, Statler-Hilton Hotel.
Oct. 17-18 Boston, Mass.

Technical Assn. of the Pulp and Paper Industry, 15th Plastics-Paper Conference, Hotel Syracuse.
Oct. 17-19 Syracuse, N. Y.

Institute of Radio Engineers, 1960 Symposium on Adaptive Control Systems, Garden City Hotel.
Oct. 17-19 Garden City, L. I., N. Y.

American Society for Metals, 1960 Metal Show, Philadelphia Trade and Convention Center.
Oct. 17-21 Philadelphia, Pa.

International Plastics Exhibition, Utrecht, The Netherlands.
Oct. 19-26

Technical Assn. of the Pulp and Paper Industry, 15th Engineering Conference, Robert Meyer Hotel.
Oct. 23-27 Jacksonville, Fla.

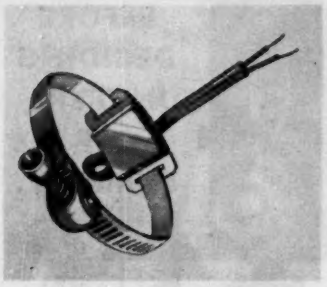
Illinois Institute of Technology, 1960 Computer Applications Symposium, Morrison Hotel.
Oct. 26-27 Chicago, Ill.

American Institute of Chemical Engineers, South Texas Section, 15th Annual Technical Meeting, Rice Hotel.
Oct. 28 Houston, Tex.

American Management Association, Packaging Management Course, Hotel Astor.
Oct. 31 New York, N. Y.

(*Continued from page* 86)

changer. Complete with recirculating pump, new unit can heat or cool liquids in tanks up to 900-gal. capacity. Combination package fits in 28 × 10-in. floor space. Pump has capacity of 5 to 15 gpm.—**Heil Process Equipment Corp., Cleveland, Ohio.** 86D

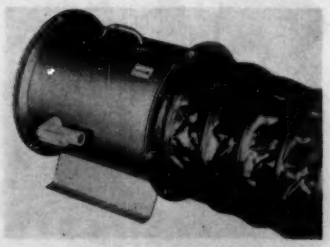


Surface Thermometer

Flexible unit matches surface on which it's pressed.

Designated RdF Strapon, new surface thermometer comes equipped with a strap-and-tension adjustment for rapid installation on pipes. It can also be immersed in fluids or molded into units where inside temperature must be measured.

Designed to operate at —100 to 500 F., units have 100-ohm CP Nickel element encapsulated in silicone rubber and stainless steel. The steel is flexible because it is only 0.002 in. thick. —**Arthur C. Ruge Assoc., Hudson, N. H.** 169A



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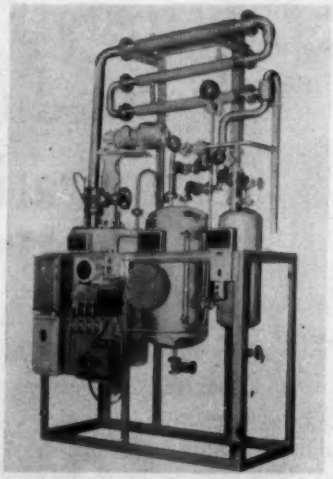
MERTZTOWN, PENNSYLVANIA

or cool overheated equipment with new portable ventilator. Designated as type PT, unit consists of fan with lengths of flexible duct which snap either on the fan or on each other. Fan propellers, of nonsparking alloy, have airfoil-section blades to overcome pressure drop in the duct.

Line includes one 16-in. and two 12-in. models. They deliver 4,150, 1,935, and 1,540 cfm., respectively. Single- or three-phase regular or explosion-proof motors have permanently lubricated bearings so fan may be mounted in any position.—**Robbins & Myers, Inc., Springfield, Ohio.** 169B



Package Pilot Plant

Reaction, distillation unit for research, production.

New compact pilot plant comes assembled, ready for installation and immediate operation. Major equipment included in the package includes stirred reactor-still pot, condenser, two receivers, and instrumentation.

Reactor pot in 30- and 50-gal. sizes is Type 316 stainless steel, heated electrically with up to 17,800 w. An 8-in. turbine mixer driven by ½-hp. drip-proof motor provides agitation. Vessels are rated for full vacuum or 150 psi., at 400 F.

Auxiliary equipment includes a fore-cut tank, temperature and pressure indicators, liquid level and pressure controllers,

PUMP PROBLEMS write TABER

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SEE TABER BULLETINS

May avoid costly pump misapplication.

Vertical pump illustrated, for handling chemicals, please request Bulletin V-837. Horizontal Pump, Bulletin C-355.

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HEAT EXCHANGERS
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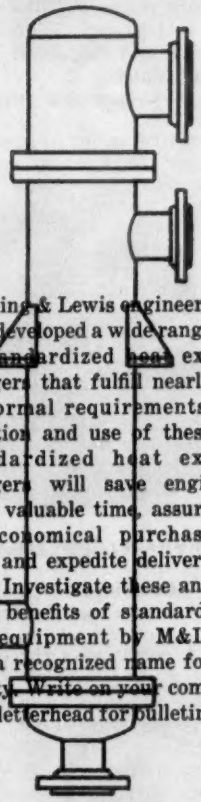

Manning & Lewis engineers have developed a wide range of standardized heat exchangers that fulfil nearly all normal requirements. Selection and use of these standardized heat exchangers will save engineers valuable time, assure an economical purchase price and expedite delivery time. Investigate these and other benefits of standardized equipment by M&L, long a recognized name for quality. Write on your company letterhead for bulletin.

In addition, a new four-color bulletin describes and illustrates the complete M&L line. Specify Bulletin 820 in your request.

M&L **MANNING & LEWIS**
Engineering Co.
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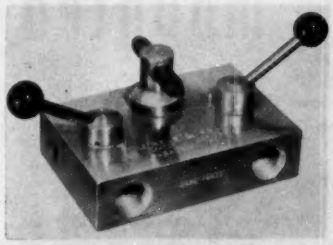
Union, New Jersey

and a vacuum pump good for 20 cfm. at 5 mm. Hg. Type 316 stainless is used for all piping; gaskets and valve packing are Teflon. For materials which require fractional distillation, a column is optional at extra cost. —**Doyle & Roth Mfg. Co., Brooklyn, N. Y.** 170A



Manifold Valve

High-pressure compact unit is three valves in one.

This manifold valve eliminates two tees, four nipples, and eight leak-potential threaded connections. Consisting of three valves in one, it withstands 2,000 psi. in systems containing air, ammonia, hydrogen, hydrocarbons, etc.

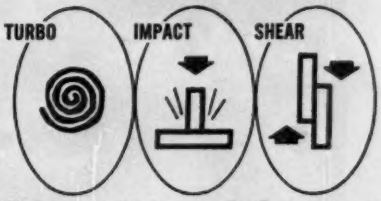
Toggle-type handle on main valves shows valve position at a glance and handle on balancing valve is color-coded for quick identification of its position. Seal design features O-rings set in grooves on the periphery of valve plugs to provide interport and body leakage. Fingertip operation is claimed for these valves in new P-727 series —**Circle Seal Products Co., Inc., Pasadena, Calif.** 171A

Pressure Regulator

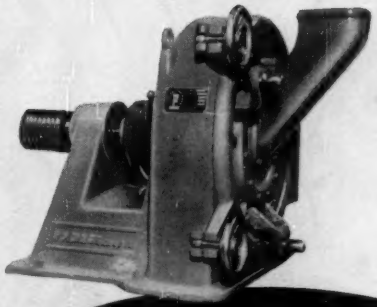
Compact, light-weight unit works to 10,000 psi.

New regulators are available for pressure reducing, back pressure service, and combination pressure reducing and relief service. Dubbed Mity-Mite, regulators are of the gas-controlled dome type which operate on the principle of balanced pressure with the valve action controlled by a pressure reaction chamber.

a NEW reduction principle
with PALLMANN PULVERIZERS



Without Internal Screens!



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2. Less Re-Cycle
3. Highest Speeds

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PALLMANN advanced design combines a high speed rotating impeller to force material against grinding liners formed by two opposing cones, thus employing three principles of reduction: TURBO, IMPACT and SHEAR.

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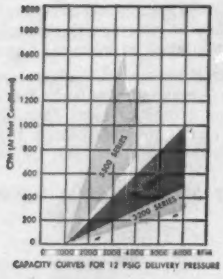
. . . PALLMANN is also equipped to do experimental and commercial run custom grinding.

new m-d engine mounted blowers

weigh only 625 lbs. Provide 400 SCFM continuous air flow



M-D answers the need for lightweight pneumatic units for vacuum or high pressure systems. Only 625 lbs. total weight of blower *and* engine. Dependable M-D units generate 15 PSIG of continuous air flow or up to 18 PSIG in surges. Ideal for mobile applications. M-D muffler packs mean quiet operation.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.

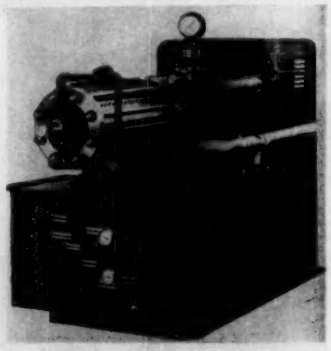
For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.

In this type valve, seat wear and valve chatter are minimized since line pressure surges or sudden changes in flow rate are opposed by pressure in the reaction chamber. A restricting orifice which connects the chamber with the dome governs the rate of pressure equalization.

Pressure reducers, ¼- to ½-in., accept inlet pressures of 10,000 psi., adjustably control to 6,000 psi. Back pressure unit, ¼-in., holds up to 3,000 psi. Combination reducing and relief regulators range to 6,000 psi., come in ¼- through 1-in. sizes.—**Grove Valve and Regulator Co., Oakland, Calif.** 171B

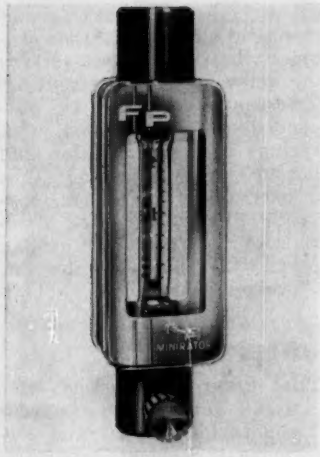


Three-Stage Reactor

Combination unit mixes, reacts and deaerates.

A continuous three-stage reactor is now available for both pilot-plant and commercial chemical processing. It consists of a series of chambers connected for series flow, each independent in performance and control. Stages are for mixing, reacting and condensing-deaerating.

Impellers for all three stages are mounted on a single shaft. The reactor provides high liquid shear in the mixing phase, no short-circuiting in the reactor, and good condensation-deaeration in the third stage using a centrifugal principal. Reactor is designed particularly for polymerization, esterification, sulfonation and similar reactions.—**Marco Development Co., Wilmington, Del.** 172A

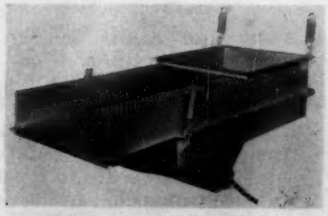


Miniature Flowmeter

Has snap-in tubes for rapid changes of capacity.

Called Minirator, new flowmeter is designed for measuring low flows of gases and liquids. Standard parts, interchangeable, speed conversion to various capacities. Tube, of the snap-in type, floats between the end fittings on O-ring seals which make it free of line vibration and misalignment stresses.

Meter may be surface or flush mounted on panel or installed directly in line. It is available with 1½ or 4-in. scales. Integral needle valve is optional; end fittings may be brass or stainless steel. — **Fischer & Porter Co., Warminster, Pa.** 173A



Screen-Feeder

Vibrating unit moves, sorts materials simultaneously.

With just one moving part, a new feeder both separates a mixed stream of solid materials (or solids and liquids) and moves them to a collection point for deposition in separate containers. A pneumatic vibrator

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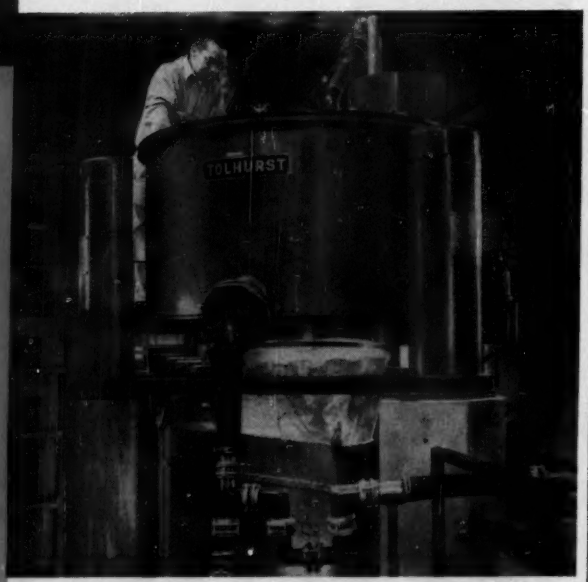

BATCH-O-MATIC® assures constant quality control

The completely automated BATCH-O-MATIC reduces exposure time to maintain product stability. Variable speed and time controls duplicate any cycle of operations. Low-speed plowing helps prevent crystal damage. Can be constructed of stainless steel, "Hastelloy," titanium or other alloys. Corrosion-resistant coatings may be specified.

The BATCH-O-MATIC handles greater out-of-balance loads with minimum vibration because of its low, compact design and *exclusive* CENTER-SLUNG® suspension.

Fast bottom discharge increases production. For complete data, see the TOLHURST section in Chemical Engineering Catalog or write Dept. CET-860 for free bulletins.

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drives both the lower tray and the upper steel screen, thus provides vibration for both screening and material movement.

Screen-feeder may be suspended or floor mounted, with springs used for flotation and not to amplify vibration. Unit is particularly useful for separating fine from coarse materials or for rinsing or cooling parts.—**Cleveland Vibrator Co., Cleveland, Ohio.** 173B

BRIEFS

Pilot dryer for plastic resins uses superheated solvent vapors for efficient and economical solvent recovery. Product does not touch heat-transfer surfaces during drying.—**Standard Steel Corp., Los Angeles, Calif.** 174A

Metalset-A-4, a metallic epoxy resin compound, can restore leaky tanks to service by sealing small openings around rivets and seams. Critical areas are sandblasted before resin is applied.—**Smooth-On Mfg. Co., Jersey City, N. J.** 174B

All-plastic safety spectacle offers wide area of coverage with single lens which covers both eyes. Packaged in individual envelopes, glasses cost only a quarter, are ideal for industrial plant visitors.—**American Optical Co., Southbridge, Mass.** 174C

Crayons and paints indicate surface temperatures of substances by changing to a different color. Crayons in 18 types measure temperatures from 150 to 1,240 F. Paints cover range from 104 to 2,460 F. Some paints change colors several times at different temperature levels.—**Air Reduction Co. Inc., New York, N. Y.** 174D

Shear-flow continuous mixer has sealed mixing chamber that eliminates air entrainment. Compact unit handles highly viscous materials in minimum time, comes in range of 1-10 h.p.—**Gabb Spe-**

cial Products, Inc., Windsor Locks, Conn. 174E

D-Stix, colored wooden sticks and rubber joints in a kit, can be used to mock up a variety of structures, such as towers, framework, piping systems, etc. for a small-scale look at big-scale installations. —**Edmund Scientific Co., Barrington, N. J.** 175A

Drum and barrel cart, operated by one man, puts full drums on pallets safely and easily. Cart has two sets of front wheels that carry a full load and facilitate unloading. Two-wheel safety brakes are optional for steep ramp operation.—**O'Neil-Irwin Mfg. Co., Lake City, Minn.** 175B

Expanded-scale thermometer amplifies small segment of the scale to full range, permits readings to a fraction of a degree. Battery-powered portable or line-operated panel units can measure temperature of gases, liquids or solids. — **Beckman Instruments, Inc., Fullerton, Calif.** 175C

Equipment Cost Indexes . . .

	Mar. 1960	June 1960
Industry		
Avg. of all	237.8	238.2
Process Industries		
Cement mfg.	232.4	236.5
Chemical	240.0	232.8
Clay products	225.8	240.1
Glass mfg.	226.6	226.2
Paint mfg.	229.7	226.6
Paper mfg.	231.3	229.8
Petroleum ind.	234.7	231.3
Rubber ind.	237.5	234.1
Process ind. avg.	236.3	237.6
Related Industries		
Elec. power equip.	242.8	242.7
Mining, milling	241.5	241.5
Refrigerating	268.4	268.5
Steam power	224.9	225.0

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124—6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.

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Photo courtesy of Kind and Knox Gelatin Company, Camden, N. J.

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The highest flow rates result from the advanced hydraulic design of NIAGARA FILTERS. Leaf design and high pressure sluicing mechanism or vibrator provide fast wet or dry cake removal and cloth washing without manual labor. Filter cloth life is lengthened.

Niagara also offers these benefits: Fully automated where feasible. Complete removal of suspended solids. Minimum floor space requirements. Low initial and maintenance costs. See NIAGARA section in Chemical Engineering Catalog for details, or write Dept. CEN-860 for bulletins.

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Step up production and cut downtime

FEinc custom designs every filter for a specific application. This insures greater yield with less downtime over longer periods of continuous operation. Standard sizes range from 5 to 800 sq. ft. of filtering area.

The FEinc STRING DISCHARGE filter eliminates blow-back and produces a cake of low moisture content. The PRECOAT filter gives high clarity of effluent and flow rates. The HORIZONTAL filter offers extremely high hourly output. A complete line of SCRAPER, ROLLER DISCHARGE and DISC filters is also available. See complete data in the FEinc section in Chemical Engineering Catalog, or write Dept. CEFE-860 for free bulletins.

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TECHNICAL

The Rewards of Research

OF MICE, MEN AND MOLECULES. By John H. Heller. Charles Scribner's Sons, New York. 176 pages. $3.95.

Short, lively and thought-provoking, this book might have been less interestingly titled "The Case for Basic Research." The author, a top researcher and founder of the New England Institute for Medical Research, in Ridgefield, Conn., mounts a soapbox in behalf of his chosen field. And he's so persuasive in doing it that one reviewer was briefly tempted to sell all worldly goods and join in the battle for funds and recognition.

According to Heller, basic research projects are almost invariably pooh-poohed, to the ultimate benefit of the applied research set, so he seeks to show what BR has done, is doing, and most important might do, with an adequate budget. Along the way, he is invariably entertaining—all too often, however, what he sees causes him great concern.

The scope of his efforts ranges widely. We are given a startling commentary on the limitations imposed upon today's medicos, not only by their instruments but by their increased need to specialize. There is an eye-opening chapter on what radio frequency waves can do to behavior patterns of living things. And the author explores the inadequacies of the national defense program.

Heller is not one to mince metaphors. Anyone sharing his belief, for example, that war via the H-bomb is not nearly so plausible as extermination of our race by means of weather control will be extremely discomforted by his remarks. And a statistic he gives is frightening: in 1955, doctoral degrees granted to Russian meteorologists numbered 630. The corresponding figure in the U. S.—2.

But not all is gloom. The reader is taken into a science-

BOOKSHELF

fictionlike world where more and more of nature's great forces are being controlled, molded into compliance by man for his needs and use.

Energy, gravity, growth are prodded and picked at by the researchers' instruments. Sharks, eels, mice, rats—all are vital to Heller's world and we are let in on the parts they play.

And always close by is the relationship this work has to man. The mind of man, the mechanism of man. And the molecules of man—indeed, the molecules of everything. In these, Heller finds an infinity of work left undone.

In clearcut style and with unrestricted enthusiasm, he has held open the core of basic research to us, while his experiments delineate fantastic fields for further investigation.—HSG

RECENT BOOKS RECEIVED

SODIUM CHLORIDE. Ed. by D. W. Kaufmann. Reinhold. $20.

REACTOR HANDBOOK. Vol. I. 2nd ed. Ed. by C. R. Tipton, Jr. Interscience. $36.50.

PROPERTIES AND STRUCTURE OF POLYMERS. By A. V. Tobolsky. Wiley. $14.50.

AN INTRODUCTION TO THE CHEMISTRY OF HETEROCYCLIC COMPOUNDS. By R. M. Acheson. Interscience. $5.

TRANSFORMERS AND GENERATORS FOR POWER SYSTEMS. By R. Langlois-Berthelot. Philosophical Library. $12.

ENGINEERING MATHEMATICS. By J. Blakey & M. Hutton. Philosophical Library. $10.

PHYSICAL METHODS OF ORGANIC CHEMISTRY. Vol. I, Part 11, 3rd ed. Ed. by A. Weissberger. Interscience. $24.50.

THE SOIL AND ITS FERTILITY. By H. Teuscher & R. Adler. Reinhold. $12.

FROZEN FREE RADICALS. By G. J. Minkoff. Interscience. $5.

Easy to use 26-page manual helps you select rotary pumps for hundreds of applications. Includes friction data on valves, fittings and pipelines; handy conversion tables for every-day use; properties of over 100 common liquids. Send for Blackmer Bulletin 33 today.

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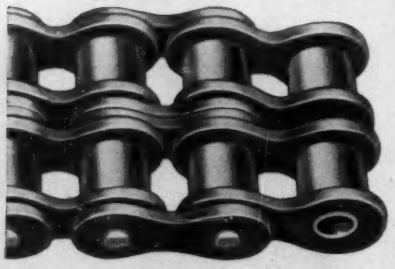
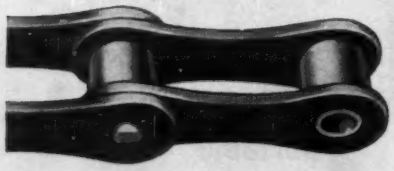
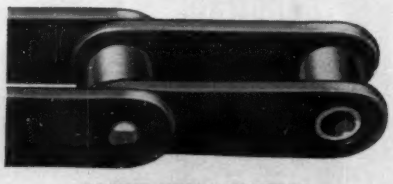


DOUBLE STRAND

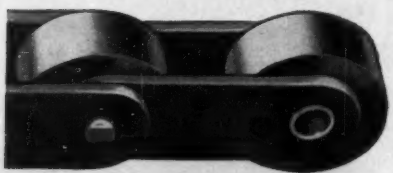
SINGLE STRAND, HEAVY SERIES



DOUBLE PITCH TRANSMISSION

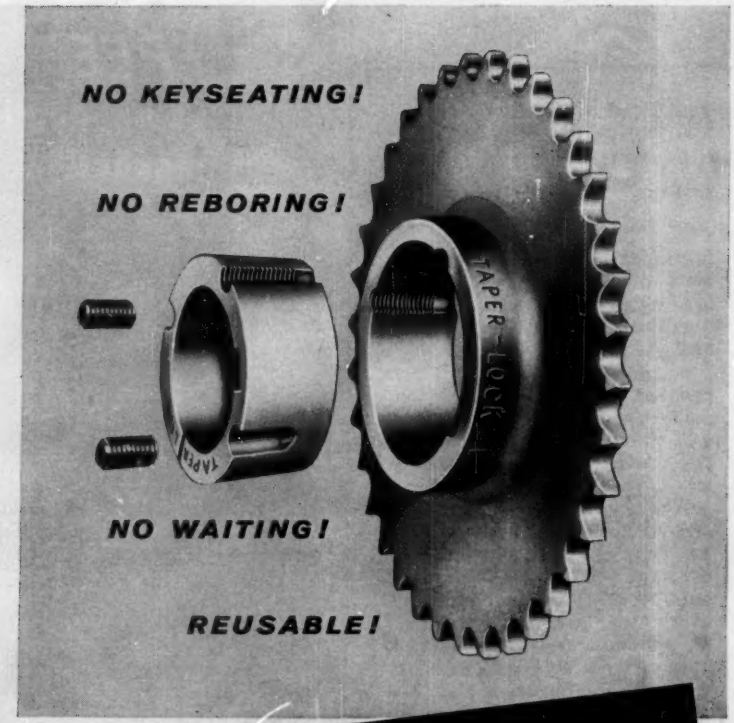


DOUBLE PITCH CONVEYOR



DOUBLE PITCH CONVEYOR, LARGE ROLLERS

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."



TAPER-LOCK SPROCKETS DODGE ROLLER CHAIN

DODGE Quality Roller Chain, teamed with Dodge Taper-Lock Sprockets, results in chain drives and chain conveyors that have the precision, efficiency and stamina necessary for the real economy of *long life*.

Moreover, Taper-Lock's reusable bushing makes a difference in overall cost. The ease of Taper-Lock mounting, the elimination of reboring, keyseating, and wasted time, add to the saving. Precision machining and true articulation lengthen the life of *both* sprocket and chain.

The Dodge line of chain, including standard attachments, is extensive. It meets a high percentage of all chain requirements.

In the Double Pitch series (both Transmission and Conveyor) the sizes which require special spacing for perfect tooth action are offered from stock in special double pitch design — to double the life of the chain and the sprocket!

Ask your local Dodge Distributor. Or write us for bulletin.

DODGE MANUFACTURING CORPORATION, 200 Union St., Mishawaka, Ind.

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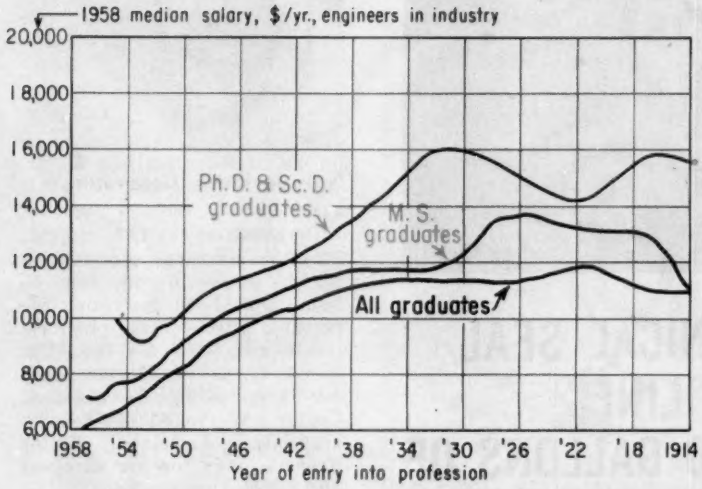
LETTERS: PRO & CON

C. H. CHILTON



What Is M.S. Worth?

Sir:

In your May 30 *Chementator* (p. 33), you report that chemical engineers with M.S. degrees earn a median of $9,932/yr., compared with median earnings of $9,818/yr. for those with B.S. degrees.

This differential of only $144/yr. hardly appears significant, considering the time and money required to obtain the M.S. degree. In fact, it would probably require close to 35 years after obtaining the M.S. for an engineer to make up financially for the minimum of one year extra schooling required to obtain the degree.

Yet in your Aug. 24, 1959, issue (p. 152), you quote Prof. C. C. Monrad of Carnegie Tech as saying, "The M.S. degree has been the optimum for the more gifted chemical engineer from the standpoint of opening various doors to success." The recent salary figures indicate relatively few "open doors."

I don't mean to be critical in any way, but I have been planning to return to school to work on my master's degree, and if the figures you have presented are accurate, I fail to see the monetary benefits I had previously believed to exist. Is it possible that the median salary figures reported are some type of statistical hocus-pocus?

JOHN K. HANE

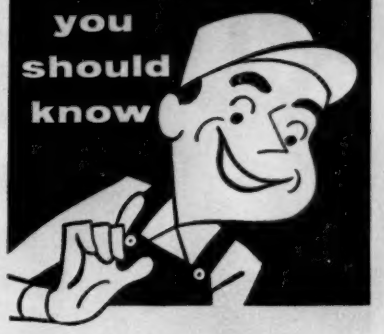
U. S. Air Force
Hill AFB, Utah

►*As indicated in our follow-up story in the June 13 issue (pp. 221-222), the statistics reported by the National Register of Scientific and Technical Personnel are beset with limitations which make it virtually impossible to draw valid, generalized conclusions from them.*

We believe that the salary data reported by Engineers Joint Council are much more reliable (Mar. 23, 1959, pp. 188-192). We have plotted EJC data in the above graph to show the earnings of engineers with advanced degrees in relation to the earnings of all engineers. Statistically, the financial advantage of the M.S. degree is more like $1,000 per year, rather than $114.

But a decision to pursue graduate study should be based on many factors other than straight monetary rewards. We would place a high value on the opinion of engineer-educator Carl Monrad.—ED.

DODGE PRODUCTS you should know



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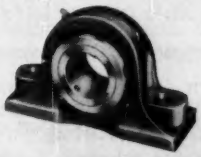

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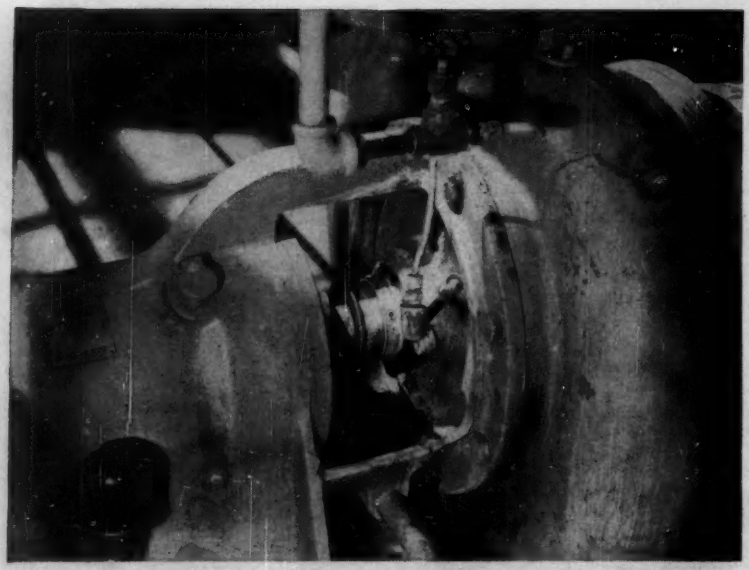

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In September, 1956, CHEMPRO MECHANICAL SEALS* were installed in 4 Allis-Chalmers high speed pumps located at the Minute Maid processing plant in Leesburg, Florida. The pumps recirculate orange juice through evaporators used to produce frozen orange concentrate.

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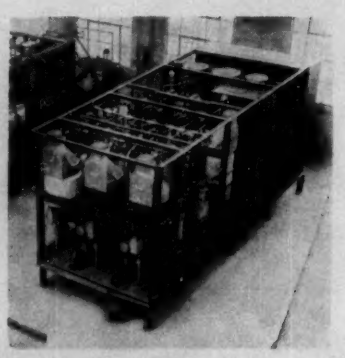

Nitrous Oxide Generator

Sir:

On behalf of the Lummus Co., let me express our appreciation for the article in your June 13 issue (pp. 84-86) describing the portable nitrous oxide plant recently completed for the U. S. Army Corps of Engineers at our Engineering Development Center. We would like to congratulate Associate Editor Frances Arne for her excellent and detailed presentation.

We would also like to express our appreciation to H. P. McKoon, Liquid Carbonic Corp., San Carlos, Calif., who made the original process design information available to us.

In the interest of accuracy, may I point out that the reference to a "hot" KOH absorber following the compressor is not strictly correct. It is required only that the temperature in this vessel be above the dewpoint of nitrous oxide.

It might also be noted that the nitrogen content of the feed to the stripping column is normally less than 1%.

SOUREN Z. AVEDIKIAN
Lummus Co.
Newark, N. J.

Pro: More Compact Files

Sir:

Please put me on record as being 100% in favor of the excellent suggestion made by M. Medwied in your May 30 issue (p. 141) concerning arranging the layout of *Chemical Engineering* such that technical information and feature articles would be separated from advertising. It sure would be a tremendous help

in compacting personal files of your articles.

The new binding has been a wonderful blessing.

JOHN C. RANDALL
Olin Mathieson Chemical Corp.
Pisgah Forest, N. C.

Van Laar Correction

Sir:

Your recent report on azeotropic distillation (May 16, pp. 121-136) was read with great interest by our process engineers. They are currently working on a separation problem similar to that described on p. 132.

They have pointed out an error in the form of the Van Laar equations (Eqs. 9 and 10, p. 124). These equations should be of the form:

$$\ln \gamma_1 = Ax_2^2 / [(A/B)\, x_1 + x_2]^2$$

One comment of my own. Prof. Coates's Ref. 12, to p. 652 in Perry's "Chemical Engineers' Handbook," rather understates the case. I believe his references should be to pp. 524-535 and 629-653.

ANDREW D. CROLL
Canadian Resins & Chemicals
Montreal, Que.

Pro: Radiation Hazards

Sir:

Your June 27 issue contained an article (pp. 105-110) entitled, "Minimizing Radiation Hazards," which is of vital interest to us. We would like very much to obtain authorization to have this article reproduced and distributed to our engineering staff.

DAVID E. GLASS
Fireman's Fund Insurance Co.
San Francisco, Calif.

Your comments and opinions are important. Send them to Editor, Chemical Engineering, 330 West 42nd St., New York 36, N. Y. They'll be welcomed.

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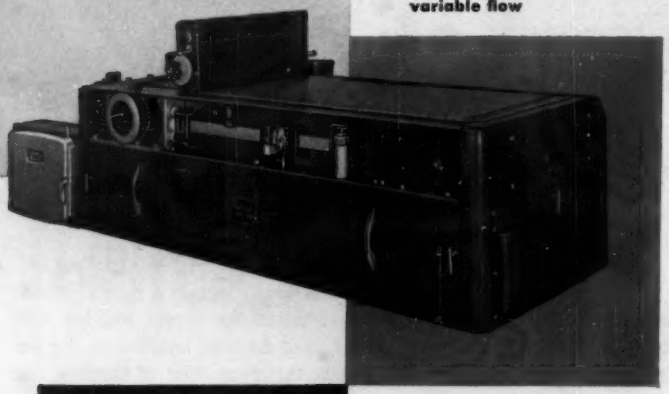

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Chemicals

Algin.....The title of this bulletin, "Emulsifying, Thickening, Suspending and Stabilizing with Algin" is self-explanatory concerning its contents and slant.
182A Kelco Company

Boron Trifluoride.....Complete technical data on the properties of Boron Trifluoride and uses of these efficient catalyst contained in available bulletins.
59 *Allied Chem., General Chem. Div.

Bromine.....Over 100 brominated compounds produced, with new ones constantly under study. Complete information on the potentials of bromine its many uses.
24 *The Dow Chemical Co.

Calcined Aluminas.....in two grades, KC-1 and KC-2, for manufacture of high-grade abrasives, refractories and ceramic products. New brochure, "Kaiser Aluminas".
165 *Kaiser Refractories & Chem. Div.

Calcium Carbide.....The making of the chemical from lime and coke and the versatility of the product are featured in a full-color, 20-page carbide and acetylene brochure.
182B National Carbide Co.

Cerium Oxide.....The brochure, "Cerium Oxide for Glass Polishing," describes rare earth processing, polishing-oxide evaluation and several theories on glass polishing.
182C Vitro Chemical Co.

Chemical.....A 32-pg. bulletin gives details on applications of Nadone. Contains complete properties, reactions and a valuable list of 148 literature references.
83 *Nat'l Aniline Div., Allied Chem.

Chemicals.....Booklets covering emulsion hydraulic fluids, oil-soluble corrosion inhibitors, home laundry softeners, and commercial softeners are available.
182D Atlas Powder Co.

LITERATURE

E. M. FLYNN

Chemicals.....All of this Corporation's chemicals are listed in this 36-page color brochure alphabetically, with physical data, uses and the major chemical use areas.
183A Food Machinery and Chem. Corp.

Coatings.....Termed a "Coatings Selector" by its maker, this booklet covers a selection of specialty coatings for application to plastics, metal, glass or wood.
183B Bee Chemical Co.

Compounds.....Armflos are preferably applied warm to hot . . . dripped, sprayed, or fogged . . . to materials in the range 100-250 F. Booklet and samples are offered.
26-27 *Armour Industrial Chemical Co.

Cryogenic Gases.....A card and a wall chart give the latest data on 34 cryogenic gases. In addition, the chart gives weight and volume equivalents on the other side.
183C Air Products, Inc.

Epoxy Resins.....5 high-temperature epoxy adhesives and potting compounds designed for service in the 450-500 F range are described in this just-released, 8-page booklet.
183D Epoxylite Corp.

Epoxy-tar coating.....Most economical coatings for different systems and the selection of these coatings is explained industry by industry in a color folder.
183E Carboline Company

Ethyl Alcohol.....150 hard-bound, full-color pages cover tables, texts, and charts on commercial data of pure ethanol, denatured ethanol, and proprietary solvents.
183F U. S. Industrial Chemicals Co.

Fiberglas.....52 pages constitute an illustrated description of the industrial applications of the continuous filament and staple fiber Fiberglas processes.
183G Owens-Corning Fiberglas Corp.

Fifth group carbides.....and their alloys with high-carbon steel is discussed in this English reprint from the Planseeberichte fur Pulvermetallurgie.
183H Chromalloy Corporation

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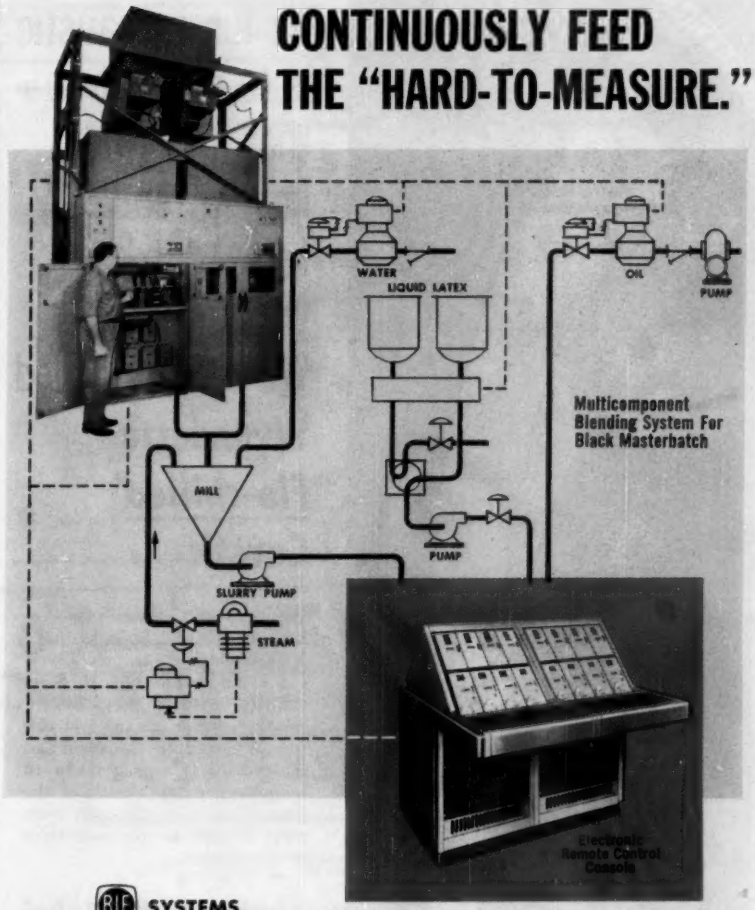

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LITERATURE . . .

Filter Aid.....Solka-Floc the new filter aid, gives more volume of clarified filtrate with absolute minimum of retention in cake. Solka Fact Folder offered.
163 *Brown Co.

Fluids and Lubricants.....A 56-page book contains sections on polyalkylene glycols, hydrolubes, brake fluids, etc., etc., and 24 pages of color charts and graphs.
184A Union Carbide Chemicals Co.

Furfural.....for new product or new process development. Additional information plus physical data on Furfural is contained in Bulletin 203-A which is offered.
73 *The Quaker Oats Co.

Indicators.....Minoxo Indicator and the Super-Sensitive Deoxo Indicator for detection and measurement of oxygen or hydrogen impurities in other gases. Literature.
4b *Engelhard Industries, Chem. Div.

Intermediates.....Alkanolamine soaps are noncorrosive, stable, and safe for skin and textiles. Booklet "Alkanolamine Soaps in Emulsions" is offered.
87-89a *The Dow Chemical Co.

Lithium.....An approach to the chemistry of lithium to distinguish it from other alkali metals is presented in Bulletin 106, a color folder titled, "Delineating Lithium."
184B Foote Mineral Co.

Lubricant.....Not only is this lubricant described (in Bulletin 126B), but a small tube containing a sample of the new ulti-purpose grease is also included.
184C The Alpha-Molykote Corp.

Lubricant.....Hi-T-Lube is a new lubricant designed for use where high temperatures do not permit use of most metal alloy or dry film lubricants. Information.
TR 196 *General Magnaplate Corp.

Lubrication.....New booklet graphically illustrates a comprehensive lubrication program. Written for plant managers & maintenance supervisors.
184D Mobil

Metal Carbides.....of tungsten, titanium, tantalum, niobium and cobalt are described and uses shown in an illustrated, 28-page booklet full of industrial photos.
184E Kennametal Inc.

Petroleum Processing.....The results of a pilot plant study where the design of cyclic thermal cracking sets were improved and natural gas produced by adding H.
184F Institute of Gas Technology

Plastic.....Full performance details of KEL-F brand Halofluorocarbon Polymers. This tough, resilient plastic has exceptionally high tensile & compression strength.
81 *Minnesota Mining & Mfg. Co.

Plastic.....Kel-F brand plastic is thermally stable, impervious to the action of corrosive chemicals & highly resistant to most organic solvents.
94 *Minnesota Mining & Mfg. Co.

Plastic.....Pioneers in the processing of "Teflon" into sheets, rods, tubes hose, tape and complete machined parts. Also complete "Teflon" service. Information.
161 *Raybestos-Manhattan, Inc.

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105d—Analytical method for sodium hydride

105e—Production & application of alcohol-free sodium alkoxides

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SOLUTION:

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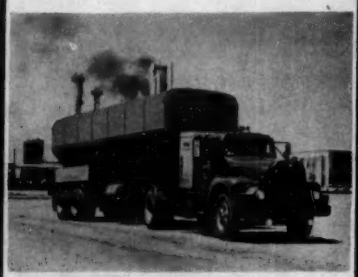
Sprout-Waldron pneumatic systems are helping industry cut costs and speed transfer of all types of material. You can get the facts by writing today for a copy of Bulletins 18-F and 208-A.

PROBLEM:

REDUCE THE COST OF MARKETING POLYSTYRENE PELLETS



SOLUTION:

SPROUT-WALDRON PNEUMATIC BULK TRUCK

Cosden Petroleum's new delivery concept is called "Curb Service Marketing." It involves distribution of polystyrene pellets by a fleet of special highway transports.

Key is group of five 28" pneumatic aluminum trailers designed and built by Sprout-Waldron. Each trailer can hold 1182 cu. ft. of polystyrene pellets.

Unloading system permits driver delivery at the rate of 30 tons per hour. Fringe expenses are cut way down. Savings are evident in unloading, warehousing, handling and in minimizing contamination. Instant inventory determination is another plus of bulk storage.

Bulletin 205-A shows how Sprout-Waldron bulk trucks are cutting handling and delivery costs in variety of industries. Copies on request.

SW SINCE 1866

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MUNCY, PENNSYLVANIA

Size Reduction • Size Classification • Mixing & Blending
Bulk Materials Handling • Pelleting & Densifying

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LITERATURE . . .

Platinum Gauze Catalyst.....Research & experience in the development of platinum gauze catalysts for the chemical industry is available. Literature offered.
4a .*Engelhard Industries

Polyalkylene Glycol.....Fluids and lubricants of polyalkylene glycol are discussed in a 56-page book which contains 24 pages of graphs and data on performance.
188A Union Carbide Chem. Co.

Polyvinylpyrrolicone.....called PVP for obvious reasons, is described as to its physico-chemical properties and its high physiological compatability in a 24-page color book.
188B Antara Chemicals

Resin Solutions.....Epon Resin solutions come to you ready-to-use, with the solvent and solids content standardized. Can be pumped with ordinary equipment. Information.
Cover *Shell Chemical Co.

Thickener.....In addition to thicking, Methocel products are used as emulsifiers, emulsion stabilizers, suspending agents, and binders. Information.
87-89b *The Dow Chemical Co.

Urethane Finishes.....These coatings for wood are set by a chemical reaction instigated by the addition of a catalyst. Bulletin 3-60 describes their applications.
188C B. B. Chemical Co.

Water Repellants.....A new silicone water repellant is claimed to retard spalling and cracking, reduce costs, prevent interior damage, and to aid in maintaining cleanliness.
188D Sonneborn Chem. and Ref. Corp.

Construction Materials

Asbestos Sheet Packing.....Compressed asbestos sheet #899 will not soften, burn, blow or ooze out of joint. Can be furnished in a variety of constructions.
157 *United States Rubber

Cements.....A complete line of sulfur silicate & resin based cements for plant-wide use in constructing corrosion-proof tanks, floors, pits, trenches & sumps. Bul. CC-3.
L170a *Atlas Mineral Products Co.

Gaskets.....The gold Flexite Finish for the metal gauge rings in Flexitallic Compression-Gauge Gaskets offers high corrosion resistance. Samples available.
93 *Flexitallic Gasket Co.

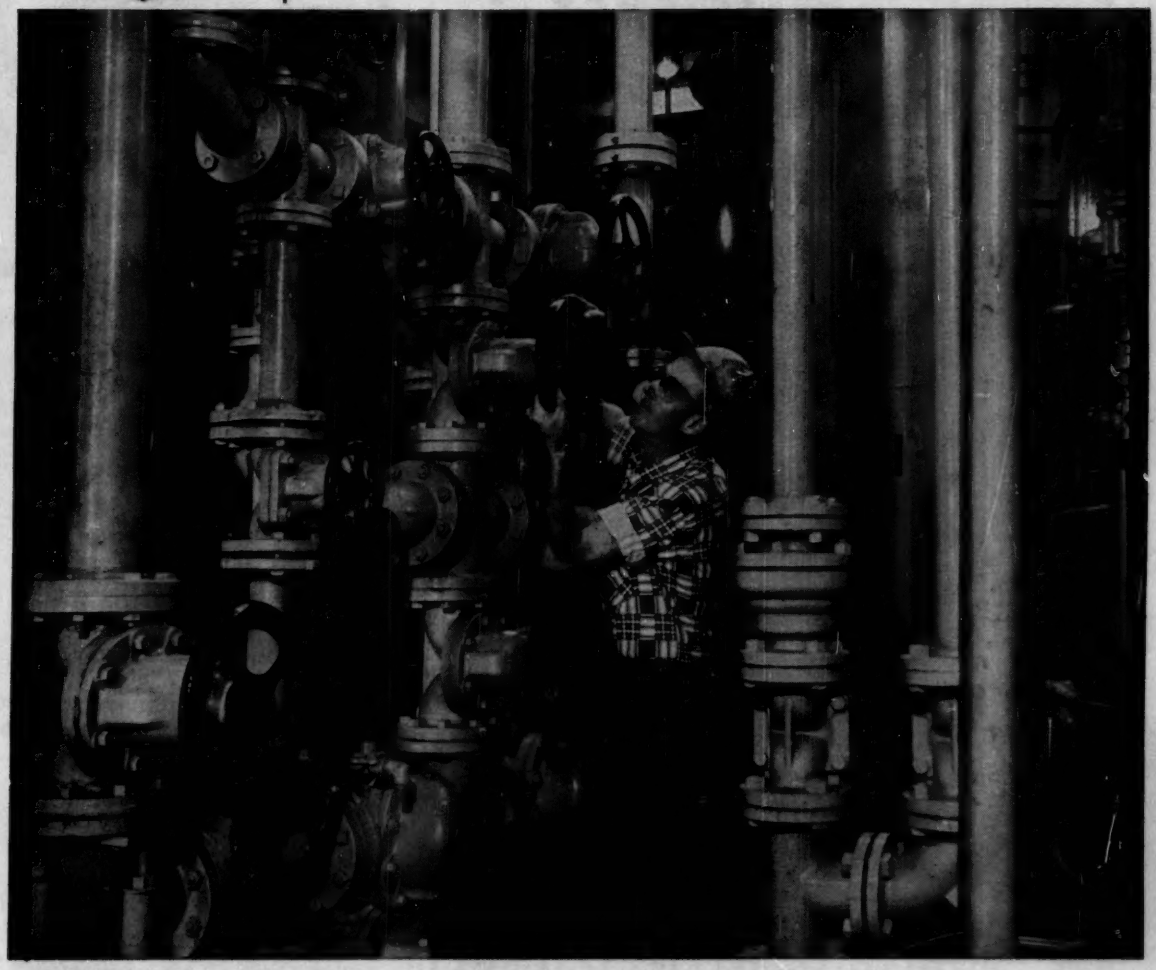
Grating and Treads.....12 pages of engineering data enable the user to identify the type wanted. Tables are also given on Safe Loads and Weights.
188E Kerringan Iron Works Co.

Insulation.....The Industrial Insulation Catalog & the American Cyanamid Case Study Report available. Also data sheets on a complete line of accessory materials.
52 *Pittsburgh Corning Corp.

Insulating Cement.....Super "66" applies quickly to any equipment, cold or hot. Effective up to 1800 F . . . & it contains a special rust inhibitive which prevents corrosion.
32 *Eagle-Picher Co.

*From advertisement, this issue

DOW | **SARAN LINED PIPE**



5 miles of pipe, 12 years of service

Saran Lined Pipe keeps process acids flowing!

When five miles of process piping must carry an unfailing flow of highly corrosive acids, thorium salt solutions and slurries . . . when frequent flow changes require quick, on-the-spot pipeline modifications . . . that's when the extreme corrosion resistance and easy workability of Saran Lined Pipe make this process pipeline a process lifeline.

Above is one section of the approximately five miles of Saran Lined Pipe which carries process chemicals in thorium recovery operations at the American Potash & Chemical Corporation's Lindsay Chemical Division plant, West Chicago, Illinois. In this process, Saran Lined Pipe is required to carry highly corrosive materials: sulphuric acid slurries for ore leaching; reacted thorium sulphate solutions and waste slurries; concentrated hydrochloric acid, hydrofluoric acid slurries. The pipe network has been in constant use since 1947, and *there's never been a major process shutdown because of pipeline failure!*

Equally as important to Lindsay as corrosion resistance are the workability and strength of Saran Lined Pipe. The nature of the process requires frequent flow changes, meaning frequent changes in piping. Necessary pipeline modifications are done quickly and easily by plant personnel, cutting process downtime to a matter of hours. And high physical strength of the pipe minimizes the need for extensive pipe supports!

Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200°F. They can be cut, fitted and modified easily in the field without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Ave., Ferndale, Michigan, Dept. 2283AK8-8.

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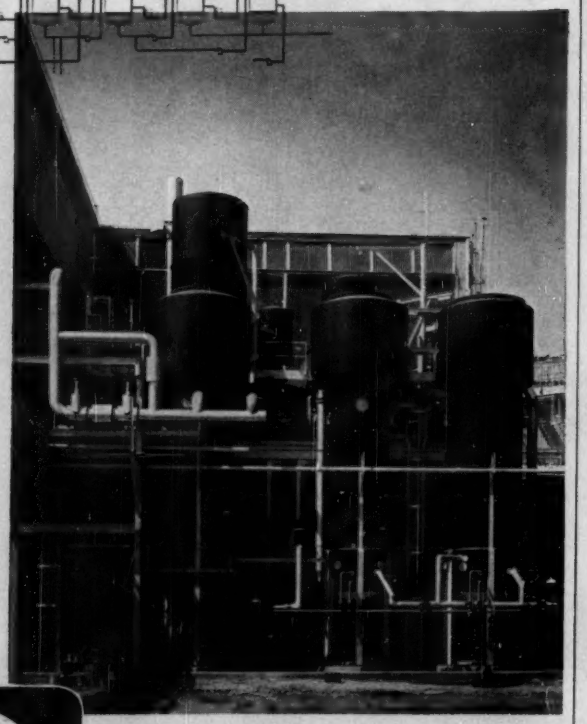

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For more detailed information write for bulletin #PP 509-1

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LITERATURE . . .

Mastic Coatings.....A resume of a recent talk before the National Association of Corrosion Engineers at Dallas covering preparation and application is available. Bul. M-1.
190A Emjay Maintenance Engineers

Metals and Alloys.....A publication has just been released containing a technical handbook on wire, rod and strip along with Federal, ASME and ASTM specifications. 44 pages.
190B Techalloy Co., Inc.

Packing, Pump.....Chempac (white) combines the excellent sealing & heat-resistant qualities of asbestos . . . with Teflon's immunity to almost all chemical & solvent action.
96a *Johns-Manville

Packing, Valve.....Thermocore (black) consists of asbestos yarns, reinforced with Inconel wire . . . braided over a plastic core of graphite & 100% white asbestos.
96b *Johns-Manville

Plastic Steel.....is a combination of approximately 80% steel & 20% of a newly developed plastic. Can be formed into any shape. Illustrated booklet.
190C Devcon Corporation

Plastic Structures.....corrosion-proof, self supporting polyvinyl chloride designed & fabricated for use as tanks, duct & fume systems to meet your exact needs. Bul. CC-3.
L176c *Atlas Mineral Products Co.

Refractory Brick.....New 24-pg. booklet can be a guidebook for your selection of the refractories you need to improve production & cut costs in high temp. processing.
43 *Norton Co. Refractories Div.

Stainless Steel.....New booklet "Design and Allegheny Stainless" is illustrated with hand-picked examples of good design in the gleaming metal. Outline of types, etc.
103 *Allegheny Ludlum Steel Corp.

Tank Linings.....natural or synthetic rubber and asphaltic materials designed to meet specific corrosive conditions within your plant. Bulletin CC-3.
L170b *Atlas Mineral Products Co.

Testing Sieves.....are accurate because the mesh is exact & there are no crevices to catch particles. Available in a complete range of sizes.
194 *Newark Wire Cloth Co.

Electrical & Mechanical

Expansion Joints.....Three types of expansion joints are available; Corruflex Packless, Ram-Pak, and Slip Type. Comprehensive catalogs are available.
42 *Yuba Consolidated, ADSCO Div.

Lighting Fixtures.....Series EV explosion-proof fixtures are easy to install & relamp. Available in choice of mountings, with a variety of reflectors. Information.
54 *Crouse-Hinds Co.

Mechanical Seals.....Seal faces are adjustable externally by single set screw arrangement. Bulletins CP-551 & 575 give information on Mechanical Seals in Tough Service.
180 *Chemical & Power Products, Inc.

*From advertisement, this issue

Motor.....Applications of a Guardistor motor to your requirements and a copy of Questions and Answers About . . . Guardistor (B-7876) are available.
8-9 *Westinghouse Electric Corp.

Motor, Electronic.....The 700J servo motor is 2 phase, size 15, 60 cycle 117 volt. Precision gearing couples the servo to a precise feed-back device with high torque. Bul.
18-19a *Taylor Instrument Co.

Motor, Pneumatic.....The 90J servo motor is essentially a power piston with a built-in positioner. Solid construction assures long, trouble-free life. Bul. 98286.
18-19b *Taylor Instrument Co.

Motors.....Features include, top-mounted gas-to-water cooler, oil pump, motor & oil filter, inert-gas temperature gauge, etc. Additional features in Bulletin No. 226.
46 *Electric Machinery Mfg. Co.

Receptacle & Plug.....New, "CES-CESD" type for all industrial equipment requiring heavy-duty circuit breaking outlets without disconnect switches ahead of outlet.
1 *Appleton Electric Co.

Rotating Shaft Seals.....A new complete catalog of this company's rotating shaft seals contains information on bellows seals, boot seals, cartridge seals, etc.
191A Cartriseal Corporation

Speed Variator.....8-page booklet describes adjustable speed drive that uses "Thyratron" tube to convert a-c to d-c power and is suitable for a wide range of applications.
191B General Electric.

Sprockets & Chains.....Taper-Lock Sprockets and Roller Chains are teamed together for efficiency in chain drives and chain conveyors. Details in bulletin.
178 *Dodge Mfg. Corp.

Switchgear.....4160-volt stored energy switchgear, called the "most compact in the electrical industry", is described in an illustrated, two-color, 20-page bulletin.
191C I-T-E Circuit Breaker Co.

Speed Reducers.....Engineering data, mounting information, service factors, horsepower, torque and overhung load ratings for seven models are given in catalog.
191D Winsmith, Inc.

Handling & Packaging

Belt Weigher.....Pneu-Weigh offers extremely high accuracies, wide ranges, capacities in compact, uncomplicated unit. Bulletin 36.20-1 for details.
182 *B-I-F Industries, Inc.

Bucket Elevators.....Complete line includes 14 types in 4 basic designs . . . centrifugal, positive, continuous and internal discharge. Complete details.
12 *Link-Belt Co.

Conveyers.....Two different pamphets, "Pneumatic Hydraulic Mechanical" and "Chip Handling and Oil Reclamation Systems," show equipment in use.
191E National Conveyors Co.

*From advertisement, this issue

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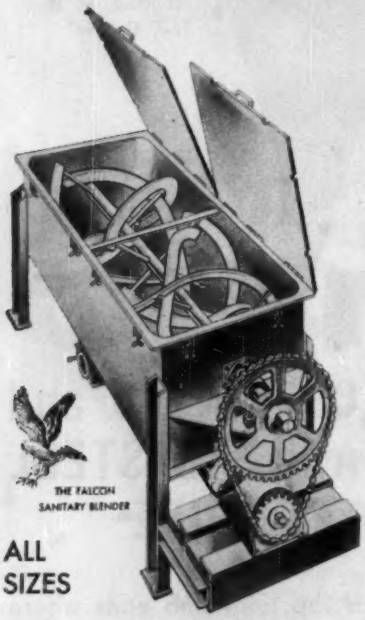

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LITERATURE . . .

Gas Transports and Storage Tubes..... This brochure illustrates and describes transports and tubes with photos and charts giving capacities and standard tube dimensions.
192A Harrisburg, Steel Company.

Pallets.....The use of pallets with industrial lift trucks and the relative merits of pallets for different industries and products is explained briefly.
192B Automatic Transportation Co.

Pneumatic Bulk Truck.....Bulletin 205-A shows how these bulk trucks are cutting handling and delivery costs in a variety of industries. Copies on request.
188a *Sprout, Waldron & Co., Inc.

Pneumatic Systems.....are helping industry cut costs & speed transfer of all types of material. Get the facts in a copy of Bulletins 18-F and 208-A.
188b *Sprout, Waldron & Co., Inc.

Scales.....Information on how these scales can streamline your plant operation is available. Operate manually or automatically. They print the weight.
L199 *Detecto Scales, Inc.

Tanks.....Brand new book originally intended for chemical sales managers contains a myriad of cost, corrosion, chemical resistance, and materials data and handbook.
192C Wendnagel & Co., Inc.

Heating & Cooling

Air Conditioning & Refrigeration Systems.....designed, installed & guaranteed systems of all types . . . for hotels, stores, hospitals, processing and industrial plants.
169 *Frick Company

Burner Systems.....Complete units for any commercial grade of fuel oil, any commercial gas (including sewer gas.) Performance data contained in Bulletin 1255.
162 *Orr & Sembower, Inc.

Extreme Temperature Equipment..... A high point of this 32-page color brochure is a pictorial chart giving atmospheric conditions up to two million feet altitude.
192D Webber Mfg. Co.

Heat Exchangers.....of the low pressure double-pipe type are described in this 8-page color brochure. The exchangers' efficiencies, sizes, and materials are listed.
192E Brown Fintube Co.

Heat Exchangers.....Condensate coolers, vapor condensers, solvent recovery units, feed water heaters, package distillation units, reboilers, all described in 16 pages.
192F Conseco Co.

Heat Exchangers.....A new four-color bulletin describes and illustrates the complete line of heat exchangers that fulfill nearly all normal requirements. Bul. 820.
L171 *Manning & Lewis Engr. Co.

Heat Exchangers.....Information on the advantages of price & excellent corrosion-resistance of "Karbate" impervious graphite shell & tube exchangers is offered.
51 *National Carbon Co.

*From advertisement, this issue

General Kinetics Corp.

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Less DOWN TIME

for MAINTENANCE and REPAIR

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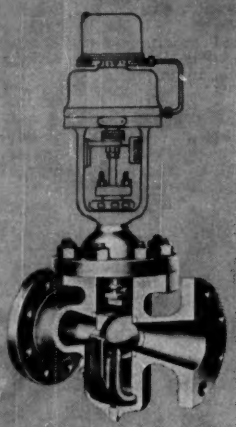

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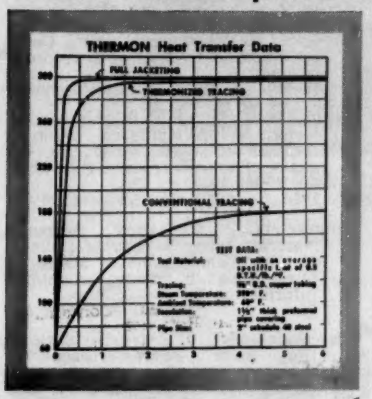

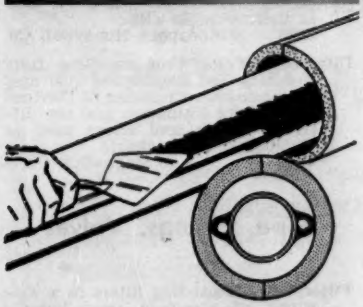

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LITERATURE . . .

Heat Exchangers, Plate.....range in size from laboratory models to capacities of over 200,000 lbs./hr. Further information available on request.
16-17a *The De Laval Separator Co.

Heat Transfer.....A complete treatment of the subject of Cost Engineering in heat transfer is now available in pamphlet form, upon request.
149 *Western Supply Co.

Heat Transfer Cement.....Thermon can be applied over both steam tracing & electrical resistance systems & is effective for heating & cooling operations. Bul. 300.
L193 *Thermon Mfg. Co.

Oven.....The complete line of High Temperature, Recirculating, Gravity, and Forced Connection ovens is listed with dimensions and cross-sectional diagrams.
193A Trent Inc.

Panelcoil.....Technical data sheet 15-60 series gives complete engineering and cost data on Dean Panelcoil. Price Bulletin 259 also available.
BL197 *Dean Products, Inc.

Steam Traps.....The 8-page Farris Mil trap catalog #FE-310 gives complete dimensional data, performance information, and capacities for all 9 types.
20-21 *Farris Engineering Corp.

Instruments & Controls

Automatic Samplers.....The sampler described in this 8-page catalog takes periodic cuts from a moving stream of wet or dry material in any stage of a process.
193B Hardinge Co.

Closed Circuit TV.....Lightly written with a serious intent, this booklet explains industrial and commercial television in laymen's language within 9 pages.
193C General Precision, Inc.

Computers.....or, more precisely, how to speak the strange language called "computerese" is explained in a 22-page glossary of terms (bit, flip-flop, nixie light, etc.).
193D Minneapolis-Honeywell Reg. Co.

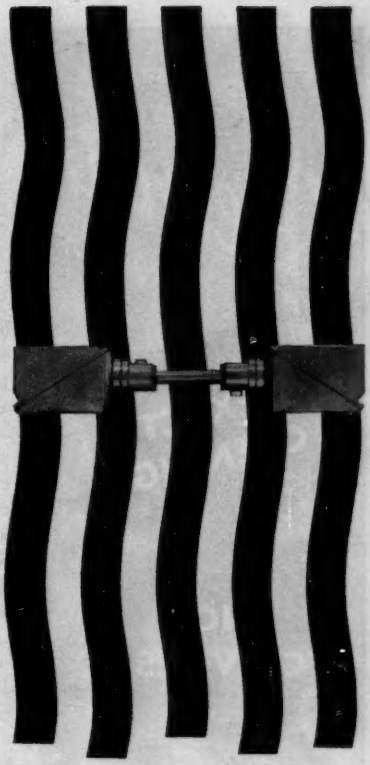
Electric Eyes.....A comparison of the human eye with photoelectric eyes is made in this 6-page brochure in explaining the working of these automation devices.
193E Photomation, Inc.

Electronic Control Station.....Consotrol stations are available for cascade, ratio and auto-selector systems. Additional information contained in Bul. 21-10.
31 *The Foxboro Co.

Enclosures.....Recognized as explosion-proof by professional organizations, these enclosures are suited for circuit breakers, relays, and control transformers.
193F Square D Company

Extrusion Control.....Laboratory features research data in the study of stock screw design, uniformity of output, compound evaluation, & advanced processing equipment.
L198 *Davis-Standard

* From advertisement, this issue



for measuring color in continuous streams

Beckman Model 77 Continuous Turbidimeter-Colorimeter takes the guesswork out of clarity and color determinations...gives rapid, accurate readings to better than ±2% of light transmission. The Model 77 consists of an Analyzer Unit and Control Unit...precision designed and ruggedly constructed to bring colorimetry to continuous process applications. Among the wide range of applications are control of water and industrial waste treatment processes, and colorimetric quality control analyses in the production of chemicals and petroleum. ⊠ Outstanding Beckman features are: ±1% repeatability... push-button scale expansion from 0-100% to 0-50% transmittance... wavelength ranges from 350 to 1000 mμ. ⊠ Complete information applicable to your specific process is available from your nearest Beckman Sales Office. Or write direct for Data File 14-33-13.

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road,
Fullerton, California

Newark TESTING SIEVES

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CLOTH RENEWABLE

If raw material control, laboratory testing or product control in your plant calls for accurate sieve testing, Newark's Standard Testing Sieves have a definite place in your plant. Made to conform with the latest specification of the National Bureau of Standards and the American Society for Testing Materials, these sieves are extremely accurate, and, as with testing instruments of all types, accuracy is of first importance. Newark Sieves are accurate because among other things the mesh is exact and there are no crevices to catch particles.

Newark Standard Testing Sieves are available in a complete range of sizes and we shall be glad to recommend the best range of meshes for your particular requirements.

Newark Wire Cloth COMPANY

VERONA AVENUE • NEWARK 4, NEW JERSEY

LITERATURE . . .

Instrument.....The Model 77 Continuous Turbidimeter-Colorimeter consists of an Analyzer Unit and Control Unit. Information applicable to your specific process.
R193 *Beckman Instruments, Inc.

Recorder.....New modular design makes all Electronik instruments easier to use and maintain. Complete details on ElectroniK recorder on request.
40-41 *Minneapolis-Honeywell

Regulators.....This catalog gives information on regulators designed for use on steam, water, air, oil, gas or chemicals from 35 F to 450 F up to 250 psig.
194A OPW-Jordan Corporation

Rotameters.....feature tempered metering tube. A copy of Bulletin 91-123, "The Rotameter Sheds Its Limitations" is offered. Contains information on Rotameters.
44 *Fischer & Porter Co.

Thermocouples.....Extensive data on the basic characteristics of thermocouple wire insulation and the different metals and alloys used as thermocouple wire.
194B Minneapolis-Honeywell Co.

Ultrasonic Tests Unit.....The fully transistorized Sonizon SO-300 may the basic characteristics of thermocouple wire insulation and the different metals and alloys used as Products Selector charts.
T210 *Magnaflux Corp.

Pipe, Fittings, Valves

Filters.....Multi-Bag filters in a wide range of standard sizes permits engineering to meet almost any dry collection requirement. Information on these & other units.
48 *Dracco Div. of Fuller Co.

Flanges.....Light weight forged carbon steel back-up flanges for use with schedule 5 and schedule 10 stainless steel stub ends and pipe. Schedule FCS-450 for prices.
191 *Camco Fittings, Inc.

Pipe.....Bonstrand is available in sizes from 2" through 8". Bulletin contains complete data, including physical properties, chem. resistance, flow rates, etc.
159 *Amercoat Corp.

Pipe.....FRP Armored pipe and fittings are readily available from inventory in standard 10 to 20-foot lengths, or tailored to meet specific requirements. Bul. FRP-1.
61 *Haveg Corp.

Pipe.....Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to to 300 psi, from below zero to 200 F. Information.
189 ..... *Saran Lined Pipe Co.

Tube.....The Story of Tube" is told in the colored photographs and illustrations contained in this new brochure. Includes the Tube Mill Products Selector charts.
194C Scovill Mfg. Co. Mill Prod. Div.

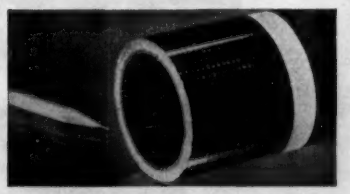
Tube & Pipe.....Fibercast offers resistance to heat, pressure & corrosion. Free sample of Fibercast and further information about Fibercast Tube & Pipe on request.
195 *Fibercast Co.

*From advertisement, this issue

TEST PROVES CORROSION RESISTANCE... Stainless Steel 316 pipe (at left) and Fibercast Pipe were tested in 54% P_2O_5 solution at 290° F using modified ASTM A-262-55T formula. The stainless steel pipe showed .778" penetration per month; yet the Fibercast showed no deterioration whatsoever.

New pipes eliminate corrosion problems in processing industries!

Chemical processing industries discover that new Fibercast® Pipe and Fittings perform indefinitely with extremely corrosive elements and high temperatures . . . even where other non-metallic pipes fail.



WHAT is Fibercast?

It is centrifugally cast, thermoset, epoxy resin reinforced pipe that handles temperature and pressure problems where no other pipe will do. Its body of woven glass fibers resists high tension forces, is embedded and bonded by heat in epoxy resin. Result: strong, long-lasting pipe that resists high pressures and temperatures in corrosive environments.

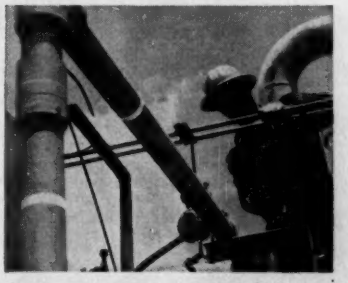
WHEN should Fibercast be used?

Whenever ease of handling, light weight, dielectric properties and structural stability are desirable in a piping material that is at the same time outstandingly resistant to heat, pressure and particularly corrosion.

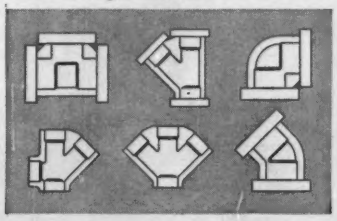
Examples: Petroleum industry . . . chemical . . . petro-chemical . . . nuclear energy . . . textile . . . paper . . . food-processing . . . and countless other operations handling acids, alkalies, salt water and other corrosive liquids under pressure.

WHY use Fibercast?

Fibercast's remarkable lasting qualities . . . its amazing resistance to "impossible" temperature and pressure conditions . . . make it a long-lived, cost-saving, maintenance-saving pipe. Remember, too: Fibercast has the world's most complete stock of standard fittings, as well as couplings designed and made to order for individual requirements.



Workman is shown with section of Fibercast pipe bearing 32% HCl at a Shell chemical plant. Note that Fibercast has sufficient strength for installation on span racks with the spacing normally used for metal pipe.



If you would like to learn more about the uses of Fibercast in chemical industries, mail the coupon below.

FIBERCAST COMPANY
Box 727, Sand Springs, Okla.

Please send me further information about Fibercast Tube and Pipe.

CE-8A

Name _____

Title _____

Firm _____

Type of Business _____

Address _____

City _____ Zone _____ State _____

FIBERCAST® COMPANY

A DIVISION OF **Youngstown** SHEET AND TUBE COMPANY

ROCKWELL VALVES *for* TIGHT SHUT-OFF

MANUAL OR AUTOMATIC

Sizes to 144"

- SPACE-SAVING
- QUICK-ACTING
- STRAIGHT-THRU FLOW

Butterfly valve with "Keelok" snap-in, easily removable, elastomer liner; for sure, tight closure and for corrosive service.

Butterfly valve with inserted rubber seat for drop-tight closure; seat replaceable at site of installation.

Write for Bulletins

W. S. ROCKWELL COMPANY
2300 Eliot St. • Fairfield, Conn.

Made and sold in Europe by
COCKBURNS, Ltd., Glasgow S.W.2, Scotland

LITERATURE . . .

Tubing.....A 48-pg. manual for data on Contour-Welded tubing in sizes from ⅛ to 40" O.D., in stainless & high alloy steels, titanium, zirconium, zircalloy & Hastelloy.
85 *Trent Tube Co.

Valves.....Iron Body Check Valves & Gate Valves may be obtained with special hard rubber linings. High resistance to corrosion & abrasion. Further information offered.
164 *Darling Valve & Mfg. Co.

Valves.....offer advantages to the processing plant where corrosion, erosion or contamination is a factor. Variety of materials available for plug facings & valve bodies.
91 *DeZurik Corp.

Valves.....Type G Sleeveline valves are available in ductile iron or stainless steel, screwed or flanged ends, from ½" through 6", with 150 psi rating. Bul.
155 *The Duriron Co., Inc.

Valves.....Monel Seat Bronze Gates are available in a wide variety. Complete information about these valves is contained in folder No. 181-C.
47 Jenkins Bros.

Valves.....Manual or automatic for tight shut-off. Sizes to 144". Feature straight-thru flow. Complete information on valves available in bulletins.
L196 *W. S. Rockwell Co.

Valves, Air Control.....2, 3 and 4-way valves that are air operated; solenoid pilot operated; that have solenoid pilot and booster; and double solenoid pilot are listed.
196A Hoffman-Odom Co.

Valves, Control.....feature positive shut-off, non-turbulent flow, low operating trust, self purging, etc. Resistant to erosion & abrasion. Tech. Catalog GV101.
R192 *General Kinetics Corp.

Valves, Diaphragm.....are available in a wide range of body, lining and diaphragm materials to meet your particular service conditions. More details on request.
102 *Grinnell Co.

Valves, Electrically Operated.....A 20-page illustrated booklet gives descriptions, specifications, features, flow charts and other data for 2, 3, and 4-way valves.
196B Airmatic Valve, Inc.

Valve, Gate.....Technical literature on the new forged steel gate valves is offered. Offers 600 psi @ 900 F; 80 psi @ 850 F; 2000 psi WOG. Send for your copy.
28-29 *Crane Co.

Valves, Lubricated Plug.....a complete line available in sizes from ½" to 36" and pressures to 15,000 lbs. Additional information on request.
34-35 *Rockwell Mfg. Co.

Process Equipment

Air Separators.....prevent blinding by removing undesirable tailings or fines from screen feed loads. Do a mechanical job of winnowing. Bulletin No. 087 for details.
R198 *Sturtevant Mill Co.

*From advertisement, this issue

THE COMPANY WITH THE DUAL ROLE!

NON-DESTRUCTIVE TESTING . . .

Complete facilities for testing products, materials and components

- Ultrasonic Thickness Measurement
- Ultrasonic Flaw Detection
- X-Ray, Gamma Ray
- Magnetic & Penetrant
- Chemical & Physical Testing

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Fully equipped for metal treating and related industrial finishing operations

HI-T-LUBE

. . . a revolutionary new lubricant designed for use where high temperatures do not permit use of most metal alloy or dry film lubricants.

GENERAL MAGNAPLATE CORPORATION
331 MAIN STREET
BELLEVILLE 9, NEW JERSEY
Territories open — Inquiries Invited

POSEY WORKS *FOR BETTER-*

Processing with PUG MILLS

Single and double shaft types for continuously blending, kneading, and feeding bulk materials. Standard or jacketed trough design.

Write for FREE 8-page illustrated brochure.

Custom Fabrication For Over 50 Years

DIVISIONS:
• Iroquois Asphalt Plants • Mixers and Blenders
• Tunnel Forms • Industrial Heating • Foundry
• Large OD Steel pipe

557 S. PRINCE STREET LANCASTER, PA.

Gas Holders

Welded aluminum tanks, pressure vessels and processing equipment for the chemical and processing industries.

Conventional or special design tanks, shop built or field erected, with flat, flanged and dished or hemispherical heads; built to your specifications, and also to ASME Code Requirements.

Send us your inquiries for elevated tanks, chemical and processing equipment for aluminum, stainless and carbon steel, Monel and other alloys. Write for "Tank Talks."

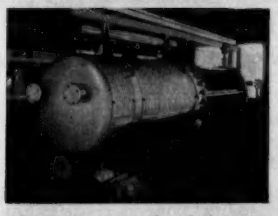
Established 1854

R. D. COLE MANUFACTURING CO.
COLE
NEWNAN, GEORGIA

HEATING HORIZONTAL TANK FILTER

with superior

DEAN® PANELCOIL
FOR HEATING—COOLING



Here's another example of the versatility of Dean Panelcoil in heating chemical processing equipment. It does the job more economically and efficiently than old style pipe coil or conventional jacketing. It takes less room, weighs less, is more attractive and gives fast, even heating. Dean Panelcoil can be formed to fit any shape or size of equipment.

For complete engineering and cost data, write for new Technical Data Sheet 15-60 Series and Price Bulletin 259.

DEAN PRODUCTS, INC.
1039 Dean St., Brooklyn 38, N. Y.
STerling 9-5400

Backed by 25 Years of Panel Coil Manufacturing

Centrifugal, Pressure.....Interior of this new model is completely & readily accessible. Specifications of the high capacity HS 40 W Universal Pressure Centrifugal.
95 *Baker Perkins Inc.

Centrifugals.....Batch-O-Matic design can handle greater out-of-balance loads with minimum vibration. Low speed plowing prevents crystal degradation. Bulletins.
174 *American Machine & Metals

Cyclones.....have the unique design feature . . . the "Shave-Off", which stops fine dust from escaping. Literature is available on these Norblo Cyclones.
104 *Buell Engineering Co., Inc.

Deionizers.....The removal of all ionizable impurities including silica and carbon dioxide from water is claimed with data given in a 6-page illustrated color booklet.
197A Elgin Softener Corporation.

Dryers.....A new bulletin #HA-308 listing all tech. specifications & capacities of the Heat-Les dynamic desiccant dryers is now available. Includes complete formulae, etc.
197B Trinity Equipment Corp.

Dust Filter.....The new "RJ" is now available in 5 sizes for handling from 300 to 6400 CFM of air (for larger capacities, multiple groupings are furnished). Bul. G-30.
160 *The Day Co.

Evaporators.....Detailed information on the unique design and the high efficiency of these evaporators is contained in Bulletin #PP 509-1 which is offered.
190 *Goslin-Birmingham Mfg. Co.

Filter Presses.....available with plates & frames of Fiberglas-reinforced polyester, Haveg, rubber, impregnated wood, & metal covered with PVC, other plastics or rubber.
T209 *T. Shriver & Co., Inc.

Filters.....Niagara filters feature advanced hydraulic design. Offer many benefits such as; minimum floor space requirements. Catalog for details.
175 *American Machine & Metals, Inc.

Filters.....FEinc filters in standard sizes range from 5 to 800 sq. ft. of filtering area. Every filter designed for a specific application. Bulletin now available.
176 *American Machine & Metals, Inc.

Filters.....with rapid cleaning devices offer advantages to the user through removal of, & subsequent disposing of waste materials or recovery of valuable solids. Bul.
50 *Industrial Filter & Pump Mfg. Co.

Flash Drying Systems.....for removal of moisture & reduction of material to a fine dry uniform finished product are described in a 28-page, illustrated catalog.
197C Combustion Engineering, Inc.

Fluidics.....16 pages give, to name a few, corrosioneering, reactions, centrifuging heat transfer, storage, agitation, ion exchange, gas analysis. flow rates and waste treatment.
197D The Permutit Co.

Gas Scrubbers.....Copy of a new brochure giving complete data on Chemico Venturi gas scrubbers is offered. Also, technical assistance on a specific problem.
25 *Chemical Construction Corp.

*From advertisement, this issue

The Company that cares enough to give you the best!

Laboratory Equipment

4"x 6" Massco Laboratory Jaw Crusher

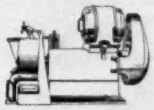
Welded steel frame; manganese steel jaw and cheek plates; bronze bushed bearings; smooth jaws give better product and easier cleaning. Adjust for plate wear and product size by convenient hand wheel adjustment.

6" and 10" Massco Gy-Roll Reduction Crusher

Reduces ½" feed to as fine as 10 mesh in single pass. High capacity, low power consumption.

Laboratory Crushing Rolls

Sizes (Diameter x width): 8"x 4", 10"x 6", 10"x 8", 12"x 10" and 12" x 12". Adjustable roll space setting up to ¾". Double V-belt drive. Heavy, cast Meehanite frame absorbs vibration, results in long life.



Massco-McCool Pulverizers

Disc type grinder with a planetary movement. No gears. Will grind ¼" to 150 mesh in one pass.

Marcy Pulp Density Scale

Gives direct reading of weight; specific gravity of liquids, pulps, and dry solids; percent solids in pulp. Very accurate. Easy to clean.

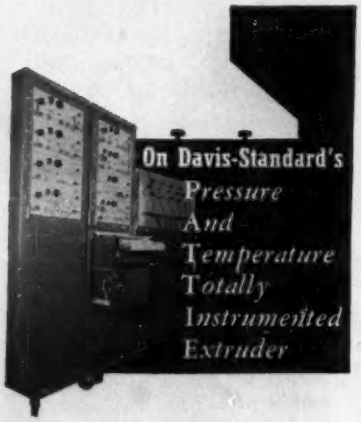
MINE AND SMELTER SUPPLY CO.

3800 RACE STREET • DENVER, COLORADO
OFFICES AND AGENTS IN PRINCIPAL CITIES

Complete

EXTRUSION DATA

Recordings



Davis-Standard has installed in their Extrusion Laboratory a completely instrumented extruder in order to provide precise research data in the study of . . .

* Stock Screw Design
* Uniformity of Output
* Compound Evaluation
* Advanced Processing Equipment

Another DAVIS-STANDARD first!!

PRECISION EXTRUSION CONTROL IS OUR BUSINESS

DAVIS-STANDARD
thermatic
10 WATER STREET, MYSTIC, CONNECTICUT

*With acknowledgment to the work of all major chemical laboratories and especially to the achievements of Dr. E. C. Bernhardt of E. I. DuPont De Nemours & Co. and Bruce Maddock of Union Carbide Chemical Co.

LITERATURE . . .

Laboratory Homogenizer.....Bulletin outlines the theory of homogenization & explains the operation of homogenizer. Lists type of products that can be processed.
198A Manton-Gaulin Mfg. Co., Inc.

Mixer.....The Lightnin CMContactor can be built to fit your process. Anything that's fluid will go through this continuous multi-stage contactor. Details.
212 *Mixing Equipment Co., Inc.

Mixers..... Flomix provide fast, uninterrupted processing. A full line of Flomix, side drive, tank top, portable and tripod mixers are available.
71 *Nettco Corp.

Mixers, Batch.....are easy to clean. Capacities: 5 quarts to 160 cu. ft. Hand and motor driven models. All sizes available in stainless steel and other alloys.
B168 *Daffin Mfg. Co.

Mixers, Portable.....are especially designed for small batch processes. Speeds of 420, 1125, & 1725 R.P.M. rated from 1/20 to 3 H.P. are standard. Bulletin No. 530-B.
181 *Eastern Industries, Inc.

Mixing.....The Multi-Mull is available in a full line of models ranging in pan retention capacities of from 6 to over 120 cu. ft. Described in new bulletin.
38-39 *National Engineering Co.

Process Systems.....A complete line of process equipment (size reduction, size classification, materials handling, bulk trucks, pelleting) is pictured and described.
198B Sprout, Waldron & Co.

Processing Equipment.....Welded aluminum tanks, pressure vessels and processing equipment for the chemical and processing industries. "Tank Talk" offered.
TL 197 *R. D. Cole Mfg. Co.

Process Equipment....Louisville Fluidized Bed dryers and coolers adapt readily to complete automation. Use less floor space because equipment is vertical. Details.
90 *General American Transp. Corp.

Pug Mills.....Single & double shaft types for continuously blending, kneading, and feeding bulk materials. Standard or jacketed trough design. 8-page brochure.
BR 196 *Posey Iron Works Inc.

Pulverizers.....the modern units for wet or dry operation, small or large capacities. Employ three principles of reduction: Turbo, Impact & Shear. Literature.
R-171 *Pallmann Pulverizers Co., Inc.

Ribbon Blender.....features all welded construction, approved sanitary design, extra heavy shafts and ribbons. All sizes are usually in stock. Brochure.
L192 *Falcon Mfg. Div. First Machinery

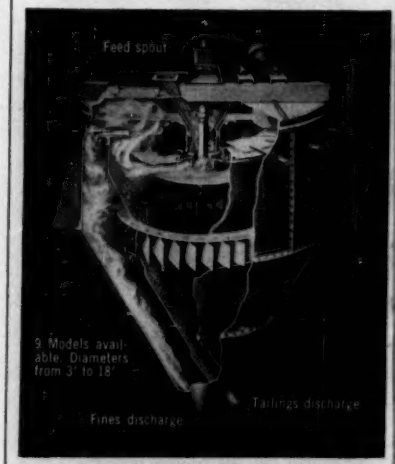
Rotary Airlock Feeders.....Complete information on Rotary Airlock Feeders for dust control and pneumatic conveying contained in Bulletin P 58.
BL 239 *Prater Pulverizer Co.

Scrubber.....The Oriclone is a new type of high energy scrubber. It is the ideal collector for fine dusts and fumes. Complete details in Bulletin W-8560.
79 *The Ducon Co., Inc.

*From advertisement, this issue

Size Requirements Getting Tougher?

Sturtevant Air Separators Increase 40 to 400 Mesh Output as Much as 300%



Closed-circuit air separation is of proved advantage in reduction processes. Result is a better, more uniform product. Grinding mills perform at top efficiency, output frequently increases as much as 300%, power costs drop as much as 50%.

Precise separation of all dry powdered materials. Sturtevants currently classify sulfur, soybeans, phosphate, chocolate, feldspar, sand and aggregates, pigments, limestone fillers, flour, abrasives, plastics, gypsum, ceramics, cement and other products.

Improve screening — Sturtevant Air Separators prevent blinding by removing undesirable tailings *or* fines from screen feed loads.

Works Like Winnowing Done In a Whirlwind

Sturtevant Air Separators do a mechanical job of winnowing. Precise control of whirlwind air currents and centrifugal force results in the desired size being lifted into fines cone, oversize falling into tailings cone.

A 16 ft. Sturtevant, for example, has taken a feed rate of 800 tph, containing only a *small* percentage of desired fines, and delivered 30 tph 90% 200 mesh, recirculating the oversize through the grinding circuit.

Send for Bulletin No. 087.

STURTEVANT
MILL COMPANY
100 Clayton St., Boston, Mass.

Crushers • Grinders • Micron-Grinders • Separators
Blenders • Granulators • Conveyors • Elevators

PUSH the button - manually or automatically...

PRINT THE WEIGHT

DETECTO SCALES

do it speedily... accurately

Find out how Detecto can streamline your plant operation. Write to..
DETECTO SCALES, INC., Dept. C-6, 540 Park Ave., Brooklyn 5, N. Y.

Men on the Move

low available in a *new edition*... with *new figures.*

his popular booklet points up the portant sales problem of personnel rnover in industry. Out of every 000 key men (over a 12-month pe- od) 343 new faces appear . . . 65 ange titles . . . 157 shift . . . and 435 ay put. These figures are based on verage mailing address changes on a t of over a million paid subscribers McGraw-Hill magazines.

rite us for a free copy

ompany Promotion Department
cGraw-Hill Publishing Co., Inc.
30 West 42nd Street,
ew York 36, New York

Scrubber.....The Joy Microdyne is extremely compact . . . 1/10 to 1/20 the size of conventional wet collectors. Descriptive literature is available.
36 *Western Precipitation

Separator.....The Syncro-Matic Separator is available in single, double and triple screen decks, regular & stainless steel. Further information on request.
16-17b *The De Laval Separator Co.

Tornado Mill.....New Size 1 is built for increased capacity. It granulates, pulverizes, disperses, & recovers scraps. Can be taken apart & cleaned thoroughly. Facts.
167 *F. J. Stokes Corp.

Pumps, Fans, Compressors

Air Compressors.....The new DMR units come completely equipped with integral motor-drive and intercooler . . . ready for operation. Bulletin No. 94 is offered.
14-15 *Cooper-Bessemer

Air Handling Equipment.....Brochure all types of fans for ventilation, air conditioning, etc. Also black coils and air washers for heating, cooling, etc.
199A *Bayley Blower Co.

Air Intakes.....Dimensions, performance data, photographs of equipment, conversion factors, all included in this 12-page brochure on fans and heating equipment.
199B Hartzell Propeller Fan Co.

Compressors.....Oil-Free Compressors feature chrome-plated cylinder walls. Resists corrosion & gives extra wear. Complete details in Bulletin 926-11.
65 *Joy Manufacturing Co.

Compressors.....Standard models or designed to your specifications in any size of compressor, either centrifugal or axial-flow types. Bulletin, "Joy Turbodynamics."
67 *Joy Mfg. Co.

Pumps.....range from 25 to 2500 hp.; presssures to 50,000 psi. Handle corrosive, viscous, abrasive or highly compressible fluids. Complete data available on request.
153 *Aldrich Pump Co.

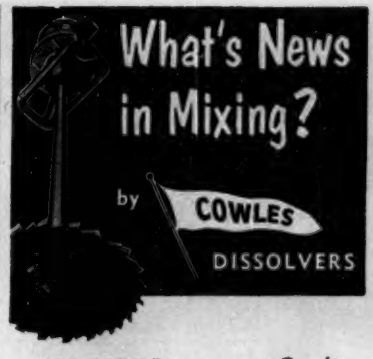
Pumps.....A six-page bulletin that illustrates and describes many types of Corblin pumps and compressors is available. Bulletin No. 4071-C.
69 *American Instrument Co., Inc

Pumps.....A type for your particular application. Bulletin V-837 describes vertical pumps and Bulletin C-355 covers the horizontal type pumps.
R 170 *Taber Pump Co.

Pumps, Acid.....Pumping parts in a variety of metal alloys, as well as plastic. 1" to 8" discharges sizes with 10 to 3000 GPM capacities & heads up to 200' & higher.
211 *A. R. Wilfley & Sons, Inc.

Pumps, Centrifugal.....Catalog contains photos & performance characteristic charts for the Centrifugal Fuel Transfer Pump & Centrifugal Cryogenic Transfer Pump series.
199C The J. C. Carter Co.

*From advertisement, this issue



"50,000" Europeans Can't Be Wrong, Either!

Actually there probably aren't 50,000 users of mixing equipment in Europe all together. But it's a big market for Cowles Dissolvers, just the same, with Cowles users increasing rapidly. Here are a few examples of performance—

1. Two major European TiO_2 producers comment that of all the equipment which they have ever tested, the Cowles Dissolver has given them the best results, often obtaining a 7½ and even a clear 8 on the N.S., or Hegman scale, (0-8).
2. A famous ink manufacturer advises that by predispersing with the Cowles Dissolver, they are able to save several passes on their 3 roller mills as follows: Milori Blue, formerly 6 passes—now 3 passes; Organic Red, formerly 8 passes—now 4 passes; Carbon Black, formerly 3 passes—now 1 pass.
3. In one of Europe's largest paper plants, a Cowles Dissolver deaerates heavy paper coating in 20 minutes, reducing the volume from 1200 liters to approximately 1000 liters.
4. A manufacturer of latex emulsions and oil base finishes reports over 42% production increase with Cowles Dissolvers for high speed dispersions. Batch-to-batch uniformity is improved substantially.
5. A major paint manufacturer produces 3,200 liters of ready ship's oil paint every hour and 20 minutes with his 40 HP 720 VHV Super Series Cowles.
6. In another leading plant a 30 HP Model 720 VH finishes 2 ton of acrylic emulsion paint in 40 minutes.

Far from being wrong, more and more European processors say they're RIGHT in choosing Cowles Dissolvers for hundreds of chemical, food, paint and similar products. You, too can get greater production in less space, at less cost, with Cowles equipment.

Let us prove it in your plant, at our risk. Write us today about your problem.

MOREHOUSE COWLES
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7150 San Fernando Road
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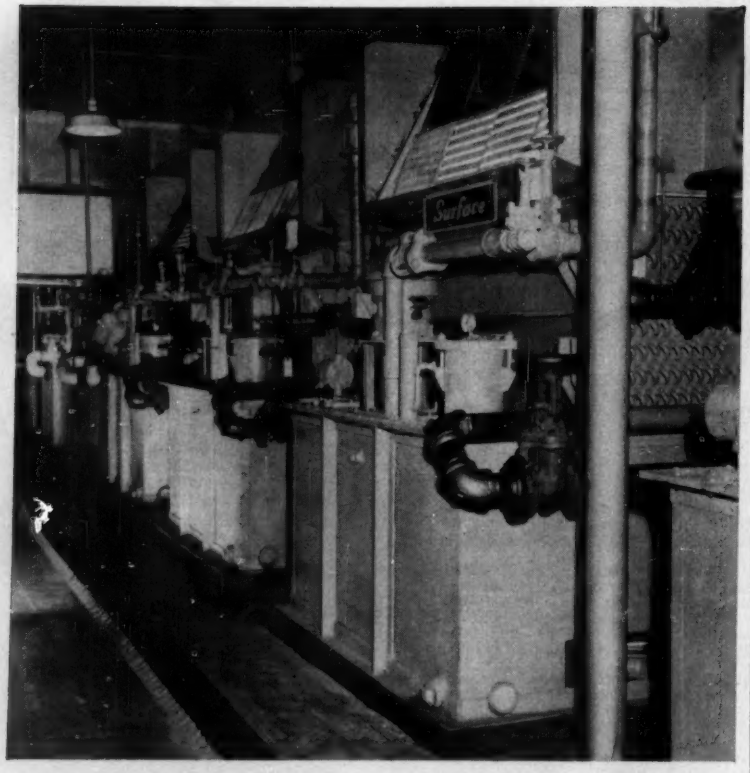

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LITERATURE . . .

Pump, Closed Coupled.....Bulletin 242 describes the Compacunit. Includes detailed diagram outlining the many features plus a Composite Rating Table.
200A Warren Pumps, Inc.

Pumps, Metering.....Pulsafeeders feature total lubrication which reduces friction to practically the theoretical minimum. New catalog 59 is available.
75 *Lapp Insulator Co., Inc.

Pumps, Rotary.....Easy to use 26-pg. manual helps you select rotary pumps for hundreds of applications. Includes friction data on valves, fittings & pipelines. Bul. 33.
T 177 *Blackmer Pump Co.

Pump, Rotary.....Brochure illustrates and describes the industrial positive-displacement rotary pump for problem liquids of high or low viscosity. Bul P-302.
200B Waukesha Foundry Co.

Pumps, Stainless Steel.....Intended for use in handling acids, alkalies, salt solutions, and organic and inorganic liquids, the pumps are designed for processing industries.
200C Sonic Engineering Corp

Services & Miscellaneous

Casting Process.....A new 56-page brochure shows the industrial applications of a new casting process with numerous photos from plants using the casting process.
200D Shaw Process Development Corp.

Fabrication.....Bulletins HE and CI contain information on materials and designs . . . all working, welding and testing operations. Quality control on all fabricating.
13 *Downington Iron Works, Inc.

General Services and Products..... Completely covering the company's operations, this booklet has chapters on tank cars, field erection, gasholders, dryers, plastic molding.
200E General American Trans. Corp.

Greek Letters.....Typing Greek letters, subscripts, exponents, and symbols used in mathematics and physics is simplified by interchangeable type for ordinary typewriter.
200F Remington-Rand Co.

Lubricating System.....Whatever your field, engineers will be glad to study your requirements and make specific recommendations. Catalog available.
166 *Manzel

Plants.....Article describing the installation of flotation & reactor plants is offered. Describes production of high quality phosphate from low grade carbonaceous ore.
200G Dorr-Oliver Inc.

Portable Fluorescent Penetrant Kit.... is ideal for finding oil leaks, tool inspection, etc. New illustrated bulletin gives complete facts on Zyglo Kit.
B 177 *Magnaflux Corp.

Water Treatment.....Four new booklets are available on the topics of recirculating cooling and process water, selection of treatment and polymetallic systems.
200H Nalco Chemical

*From advertisement, this issue

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C-I-L

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(Employment opportunities con't on page 202)

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Member, A.I.M.E., 51, 20 yr. exp. supervisor, plant operation & maint. in lime, clay prod., compressed gas mfg.; also exp. as corporate officer. Prefer position with small company where versatility is of maximum advantage. PW-4896, Chemical Engineering.

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CE's Searchlight spots the big bargains in used, resale and rental equipment. Check this issue's listings—most complete in the field—for items you need now

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TANKS: 3,800, 4,500 and 6,500 Gal. S/S lined.
MILLS: Fitzpatrick Mod B 6 SS; Mikro 2TH; Prater 009; Rietz disintegrator Mod RD 18 P.
HEAT EXCHANGERS: Foster Wheeler from 79 to 520 sq. ft. heating surface, type 316 SS tubes & Crown sheets. Priced to sell.

Send us your lists of idle equipment

AARON EQUIPMENT CO.
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Schiller Park, Illinois
Gladstone 1-1500

CIRCLE A ON READER SERVICE CARD

Baker Perkins 150 gal 40 HP, 100 gal 50 HP. Both S.S. 2 arm jacketed vacuum hdr. tilt.
Aluminum Condenser 350 sq ft.
Aluminum Evaporator Calandria type, never used. 1300 sq feet tube area.
Continuous Stripping column 2 x 13 Steel.
Hydraulic Pumps & Motors.
Dryers Vacuum Shelf.

MACHINECRAFT CORPORATION
800 Wilson Ave. (East of Doremus)
Newark 5, N. J. MI 2-7634

CIRCLE E ON READER SERVICE CARD

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Louisville 54" x 35' long Rotary Monel Steam Tube Dryer. 1120 sq. ft. heating surface. 150# pressure. Code construction. New 1954.

Used only 1 year

MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE B ON READER SERVICE CARD

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IMMEDIATELY AVAILABLE, 4—Lawrence Type 3-S Vertical Top Suction Slurry Pumps. MATERIAL: Carpenter 20, CAPACITY: 80-350 GPM, HEAD: 40-120 Ft., MOTOR: 10 HP, TEFC, 1200 RPM CONDITION: Good—used COMPLETE SET SPARE PARTS

INDUSTRIAL PROCESS EQUIPMENT CO.
4829 Goodfellow Blvd., St. Louis, Mo.
Phone: EV. 5-4321

CIRCLE F ON READER SERVICE CARD

AUGUST SPECIALS

Gen. American 42" x 120" Twin Drum Dryer
Gruendler "BB" Hammermill, Whirlbeater
Day #4 gearless 80 gal. Pony Mixer, 10 hp.
Pfaudler 1500 gal. glass enclosed top Tank
Colton #5½ Preformer, max. size 3" x 2½" tablet
Abbe 5' x 6' J'ktd. Ball Mill, chrome manq. steel
2 Oliver Rotary Vac. Filters, 3' x 2', 63" x 8'
3 Bird Filters, 18" x 28", 4' x 1' & 24"
Ribbon Blenders, Steel & SS, all sizes, New & Used

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YOU CAN BANK ON

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2—Tolhurst 48" perf. basket S.S. Centrifuges. Complete

1—J. H. Day Cincinnatus 100 gal Sigma Mixer. Size 6 Class 6

9—Stainless Steel Tanks. 250, 350, 500 & 1000 gal. In Stock

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2—French Model S-2 Expellors

3—Elmco 8' x 12' Rotary Cont. Vac. Filter. Steel closed drum

2—6' x 50' Rotary Flame Dryers. ½" shell. 15 HP Mtr. Fan

For immediate quote, wire or phone collect—GA 1-1380

MACHINERY AND EQUIPMENT COMPANY
123 Townsend St. · San Francisco 7, California

CIRCLE H ON READER SERVICE CARD

SPECIAL

BUFFALO 32"x90" DOUBLE DRUM DRYER

Centrifugals: 12", 30", 40" & 48".
Centrifuges: Sharples #5 & #6 Stainless.
Dryers: Hersey 5'x26' Rotary, 316 Stainless
Buffalo Vac. Drum Dryer 24"x20".
Despatch Ovens Elec. Heated.
Devine Vac. 8 shelf Dryer 38" x 42".
Hope Stainless Can Filler pts. to gals.
Filters: Vallez 49 S. S. covered leaves.
#2 Sweetland 12 Stainless Leaves.
Filter Presses: 6" to 36" Iron & Wood.
Kettles: S.S. Jac. 20 to 500 gals.
Dopp 350 gal. cast iron Jack. Vacuum.
Devine Impreg. Units 30" & 36" dia.
Mills: Raymond #00, 30 HP. & #0000.
Mikro Pulverizers #4, 2, 1, & Bantam.
Hammer Mills & Pulverizers 3 to 50 HP.
Rotary Cutters 1½ to 5 HP. & up.
Spr. Waldron Stainless spike crusher.
Pebble, Jar & Ball Mills, Lab. to 6' x 8'.
3 Roll, 9" x 32", 12" x 30", 16" x 40".
Lehman 4 Roll W.C. 12' x 36" Steel.
Colloid Mills 1½ H.P. & up.
Mixers: Baker Perkins jack. 100 gals.
Day Imperial 75 & 150 gals.
Change Can Mixers 8, 15, 40 gals.
Sprout-Wald. 10,000# horiz. Spiral Mixer
Day Jumbo 700 gal. horiz. mixer.
Blystone 3000# horiz. spiral mixer.
Day 1000# Ribbon Mixer & other sizes.
Lancaster 6' dia. 25 HP. & #1, HP.
Pumps: Stokes etc. Vac. 10 to 500 CFM.
Gould 75 HP. Centrifugal 250 PSI.
Sifters: Day, Robinson, Rotex type.
Tablet Machines: Stokes Rotary RD3
Colton 4½T & 2B Single Punch
Hydr. Presser, Plastic & Rubber Machy.
Partial Listings. Write for Bulletins

STEIN EQUIPT. CO.
107-8th St., Brooklyn 15, N. Y. Sterling 8-1944

CIRCLE J ON READER SERVICE CARD

LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: Tolhurst 20" st. steel (New).
Centrifugal: AT&M 60" st. st. perf.
Concentrating Table: Deister #14, 5' x 8'.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Rietz RD18P, 75 hp.
Dryers: Devine 2 x 4' vac. drum, st. steel.
Dryer: Bowen lab. spray st. steel.
Dryer: American atmospheric 24 x 48".
Dryer: Devine #7 13-shelf 60" x 7'.
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Oliver precoat 12 x 2" st. steel.
Filter: Elmco st. st. drum 16" x 12".
Filter Press: Shriver 24" St. steel.
Heat Exchangers: 400 sq. ft. st. st. tubes.
Homogenizers-Disperser: Tri-Homo #10, #4.
Kettles: st. steel with and without ag.
Dopp 150 gal. dbl. act. agitator.
Mills: Mikro Atomizer 5MA st. steel.
Day 3-roll high speed 14 x 30".
Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
Mix-Muller: Simpson Porto 39" st. steel.
Pumps: Rotary, gear, centrif., vacuum.
Screen: Rotex model 41 st. steel.
Tablet Press: Stokes DD2, 23 station.
Vacuum Pans: 42" and 72" stain. steel.

LOEB EQUIPMENT SUPPLY CO.
820 WEST SUPERIOR ST. · TELEPHONE SEeley 8-1431 · CHICAGO 22, ILLINOIS

CIRCLE K ON READER SERVICE CARD

AGITATOR—S/S w/10 HP xpl. proof 2 spd motor, 3" shaft x 6' long w/propeller—1 HP Lightnin' 1150 RPM

SCREENS—12" x 72" S/S Ajax—20 x 84, 20 x 96 Rotex—3 x 5, 3 x 10 Tyler Hummer

FEEDERS—S/S Vibrating 4½ x 24, 24 x 72 Syntron—Hardinge B Constant Weight

MILLS PULVERIZING—3 HP Sturtevant 00—10 HP Mikro 2 TH—30 HP Raymond—50 HP Mikro 3 TH w/Mikro Collector (unused)—100 HP Jeffrey 36 x 42—250 HP non-clog—450 HP Penns. SXT 14.

DRYERS, ROTARY—24" x 22', 3' x 24', 4' x 40', 5' x 50', 6' x 30', 7' x 58' all w/motor drives

DRYER, VACUUM SHELF—w/13 shelves 59" x 78", total area 356 sq. ft.

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4' Telsmith TY Gyratory Crusher
2—Wemco 2M-HMS Plants
No. 5060 Dixie Mogul Hammermill 500 HP
No. 1 Sturtevant Rotary Fine Reduction Crusher
72" x 28' Madison Rotary Dryer
F55 Syntron Grizzley Feeder
10—1½ & 2 Yd. V-Shape Dump Cars
2—5' x 8' KVS Air Swept Ball Tube Mills
Ball Mills: No. 56, 6' x 4', 6' x 6' & 7' x 22'
Hardinge Mills: 3'x8', 3'x24", 6'x48" & 10'x48"
Rod Mills: 4' x 11', 6' x 12' & 7' x 15'
Jaw Crushers: 10" x 20", 14" x 28", 15" x 24", 39" x 36", 48" x 72" & 56" x 72"
Crushers, Fine Reduction: 22", 2', 3', 5½' Cone, & 40" x 22" Roll
Rotary Dryers: 3'x30', 5'x30', 6'x70' & 8'x80'
Rotary Kilns: 36" x 30', 6' x 70' & 9' x 160'
Roto Louver #207-10 Type 316 SS, Link Belt
Louisville Monel Steam Tube Dryer, 54" x 35'
Laboratory Rotary Kiln, 36" x 30'. Complete
4' x 10' Tyler-Hummer Electric Vibrating Screen
3' x 12' Seco Single Deck Vibrating Screen
8' x 16' Gayco Centrifugal Air Separator
24" x 95' Hewitt Robins NEW Truss Belt Conveyor
6—30" x 32" Dings Magnetic Head Pulleys
3—Inger.-Rand 2200 & 3051 CFM Compressors
2000 Tons Steel Sheet Piling, 10' to 78'
2—150 HP, 1—200 HP S.D. Elec. Hoists

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P	2,000,000 ft. 2"....3.50# to the foot	P
I	1,000,000 ft. 3"....7.70#	I
P	1,000,000 ft. 4"....10.98#	P
E	500,000 ft. 6"....19.80#	E
	200,000 ft. 8⅝"....28#	
	400,000 ft. 10¾"....35#	
	75,000 ft. 12¾"....40#	

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COLUMBUS 19, OHIO

CIRCLE N ON READER SERVICE CARD

BUY BRILL

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Sharples C-27 Super-D-Hydrator, 316 S.S. Monel.
Bird 18"x28", Solid Bowl, Continuous, 316 S.S.
Bird 36"x50", Solid Bowl, Continuous, 347 S.S.
Sharples PY14, PN14 Super-D-Canters 316 S.S.
Tolhurst 26" susp. Rubber Imperforate Basket.
Fletcher 48" susp. 304 S.S. Perforated Basket.

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650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1400 gal. Blaw-Knox, steel, jacketed, agitated Reactor.
550 sq. ft. Buflovak monel single effect Evaporator.
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750 gal. nickel clad Mixing Tank, 125# nickel coils.
4000 gal. Haveg Vert. Tank, 8'x12'.
1500 gal. Stainless Pressure Tank, 5'x10', 90#.
12,000 gal. horiz. steel Pressure Tank, 7'6"x36', 200 psi.
Stainless Steel Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
Falls Industries 100 sq. ft. Karbate Condenser.
24" dia. x 35', 304 S.S. Bubble Cap Column.

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Oliver 6' dia. Horizontal Filter, 316 S.S.
Oliver 3'x2' S.S. Rotary Vacuum.
U.S. 200 sq. ft. 304 S.S. Auto-jet Filter.
Oliver 5'3"x8' Steel Rotary Vacuum vaportite housing.
Feine 5'x6' Stainless Steel Rotary Vacuum Filter.
#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

DRYERS

Buflovak vacuum Shelf with 20—60"x80" shelves.
Devine Vacuum Shelf with 10—40"x43" shelves.
Buflovak 42"x120", double drum Dryers.
Devine 4'x9', single drum, atmospheric.
Buflovak 3'x10' Rotary Vacuum Dryer.
Bonnet 5'x40' Rotary Kiln with 3'x36' cooler.
Louisville Rotary Steam Tube 6'x25', 6'x50'.
Louisville 8'x50' Stainless Steel lined Rotary Dryers.
Rotary Dryers, 34"x30', 6'x50', 6'x60', 7'x80', 8'x87'.
Traylor 30"x18' Stainless Steel Rotary Dryer.
Atmos. Tray Dryers, 16 shelves, 40"x24".
P&S 10' wide Apron Conveyor Dryer 48' long.

MIXERS

Banbury #B, 7½ H.P. U.S. Vari Drive.
Baker Perkins 100 gal., jacketed, double arm, 30 HP.
Baker Perkins #16TRM, 150 gal., jktd., Vac. 60 HP.
Baker Perkins 50 gal. jacketed, double arm.
Baker Perkins 10 gal. jacketed 304 S.S. sigma blades, vacuum.
Day "Cincinnatus" double arm, 250 and 100 gal.
3' dia. Simpson intensive Mixer.
Stokes 21K, 304 S.S. Granulating Mixer 82 gal.

MISCELLANEOUS

Farrel 8"x16", 2 Roll Mill, 15 H.P.
ISH, 1SI Mikro Pulverizers, 3 HP.
Abbe 2½x3' porcelain lined Pebble Mill XP motor.
Abbe #4 Eureka Jar Mills, 21 gals.
Raymond 10' dia. Single Whizzer Separator.
#5 Mikro Atomizer with motor and cyclone.
Bantam Mikro Pulverizers, S.S.
No. 1 Ball & Jewell Rotary Cutter.
Swenson Walker Continuous Crystallizers, 24" x 30' sections.
#12 Rotex Sifter 20"x40", double deck; #22 Rotex Sifter 40"x56", double deck.
#24 Rotex Sifter, 20"x64", Quadruple deck.
Stokes, DD2, DDS2 T, "R", and "F" Tablet Presses.
Nash Vacuum Pumps: H6, T57, #2.

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CIRCLE G ON READER SERVICE CARD

MORE MIXERS than ANYBODY

Baker Perkins Heavy Duty Double Arm Jacketed Units, 300 gal., 200 gal., 100 gal.

Day Cincinnatus Stainless Jacketed Double Arm Mixer, 300 gal. capacity; XPL motor.

2 Horizontal Type "C" Versators; 316 Stainless. Jacketed Steel Ball Mills; up to 54" x 42".

International Porcelain Lined Pebble Mills, 8' x 8' motorized with 50 HP Gear Motors.

Raymond Imp Mills; most models in stock.

Jackson & Church Vertical Autoclave; 41" x 54"; Jacketed; 300 gal.; quick opening.

BRAND NEW FALCON RIBBON BLENDERS . . . in Mild or Stainless Steel; all sizes stocked.

Condensers and Heat Exchangers absolutely the BIGGEST STOCK; many in STAINLESS.

Stainless Steel Columns and Towers; many types.

Tablet Presses by Stokes, Colton, Kux; many Models in Rotary and Single Punch; all sizes.

Stainless Steel Kettles and Reactors; many with agitators; Jacketed and Unjacketed.

Stainless Crystallizer or Pan Dryer 250 Gal. 85" x 24", Jktd. Agitated.

Zaremba Dbl. Effect INCONEL Evaporator.

Bowen Stainless Steel Spray Dryer. Louisville MONEL Rotary Steam Tube Dryer; 54" x 35'.

Struthers Wells STAINLESS Drum Dryers; 5' x 4' and 5' x 10'. Nickel Plated Dri Drums 4' x 4'.

2 MONEL Reactors, 2800 Gal. with Turbine Agts. Jktd. 175# ASME.

Struthers Wells Type 316 S/S 2000 Gal. Jktd. Agtd. Reactors. NICKEL Clad Reactor; 7' x 11'6".

Lancaster STAINLESS Lined Rot. Reactor; Jktd. 50" x 17'4". STAINLESS Vac. Still 755 Gal.

14 STAINLESS Pressure Tanks 700 Gal.

2 Stainless Lined 11,000 Gal. Pressure Tanks; 10' x 18'7".

STAINLESS Dbl. Arm Vac. Mixer; 150 Gal.

2 Lehmann Amalgamators; S/S Lined; 32" x 44".

Patterson-Kelley STAINLESS Twin Shell Blenders; 30-150 cu. ft.

Oliver Dorrco NICKEL Rot. Vac. Filter; 6' x 3'.

Oliver Precoat Pressure Filter STAINLESS STEEL 5'3" x 8'. FEINC S.S. Rot. Vac. Filter 6' x 6'.

Oliver Precoat Pressure Filter MONEL 3' x 2'.

Send for FIRST Facts

FIRST MACHINERY CORP.
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CHEMICAL EQUIPMENT DIVISION

Raymond 3 Roll #3036 Hi-Side Mill
Buflovak 18 Shell Vacuum Shelf Dryer
1000 sq. ft. Stainless Heat Exchangers (2)
Tolhurst 40" S.S. Center Slung Centrif.
Fletcher 40" Susp. Steel Centrifugal
Sweetland #12, #10, #7 Filter Presses
30 Gal. S.S. Jktd. Autoclave 1000 PSI Int.
Shriver 30"x30" P&F 36 C.I. Chambers
Nooter 750 gal. Steel Reactor 300 PSI
Traylor 8' x 11' Ball Mill
Allis-Chal. 8'x80'x5⅝" Welded Rotary Kilns
Vulcan 6'x124'x½" Rotary Kiln
Link Belt 502-16 Roto-Louvre Dryer
8' x 80' Rotary Dryer 316 S.S.
Mosser 4' x 47' Rotary Dryers
Louisville 6'x50'; 6'x25' Steam Tube Dryer
Stainless Tanks 100, 200, 350 gal.
Condensers 100 to 5000 sq. ft. Steel; Admir.
Pressure Vessels 300 to 4500 gal.
Dixie #5060 Mogul Hammermill
Raymond #30, #40 Impact Mills

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110 CFM 3000 PSI Ing. GC 50BW
138 CFM 100 PSI 7x7, Ing. ES, CP & Joy
151 CFM 3000 PSI 13¾x12 Norwalk TRS-4T
288 CFM 100 PSI 9x9 Ing. Worth. CP & Penn
311 CFM 1500 PSI 10½-7¼-3¼x13 IR-ES3
351 CFM 350 PSI 11-5x11 CP TCB-2
401 SCFM 350 PSI IR ESH2 (New)
465 CFM 100 PSI 12x11-IR-ES-1-Chic. P.T.
660 CFM 125 PSI 11¼-7x7 Joy Wn 102
686 CFM 100 PSI 14x13 Ing. ES-Chic. P.T.
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1600 CFM (actual) 100 PSI C300-300H Fuller
1721 CFM 110 PSI 23-14x16 Ing. PRE2
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CIRCLE Q ON READER SERVICE CARD

Oliver Rotary Vacuum Filter

74" dia. by 51" face, cloth covered open drum, stainless steel contact parts, good condition.

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24" x 45", 10 gauge, 400 PSI, type 304, ¼" pipe thread each end. *NEW*, $300 value, $99.50. Size 8½" x 18", 16 gauge, $14.50. Case of 8, $14.25. F.O.B. Baton Rouge, Louisiana.

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2—Davenport 8′ x 60′ rotary dryers, 7/16″ welded shell.

2—Louisville 7′ x 70′ rotary kilns, ½″ welded shell.

1—Patterson 6′ x 10′ pebble mill, porcelain, jktd.

1—Buflovak 700 sq. ft. T304 SS single effect forced circulation evaporator, complete.

1—Buflovak 5′ x 30′ T316 SS rotary vacuum dryer.

2—Buflovak vacuum shelf dryers: 110, 98 sq. ft.

STAINLESS STEEL TANKS

1—17,650 gal. horiz., T316 SS, 9′ x 35′, 40# WP

1—3700 gal. vert., T304 SS, 6′ x 17′, VAC.

1—3300 gal. vert., T304 SS, 6′ x 14′

1—2750 gal. vert., T316 SS, 7′ x 8′, 50# WP

2—2600 gal. vert., T316 SS, 7′ x 8′, Agit.

1—2500 gal. vert., T316 SS, 7′ x 7′, 70# WP

4—2250 gal. vert., T316 SS, 7′ x 6′, 70# WP

1—2100 gal. vert., T316 SS, 6′ x 10′

1—1900 gal. vert., T316 SS, 6′ x 8′, VAC.

12—1750 gal. vert. hoppers, T304 SS

MIXERS

60—200 gal. Baker-Perkins, sigma, jkt.

1—150 gal. Baker-Perkins, sigma, jkt.

3—100 gal. Baker-Perkins, sigma, jkt.

1—100 gal. Baker-Perkins #15-UUMM, disp. blades, 100 HP, jkt., comp. cover

1—100 gal. J. H. Day, sigma, T304 SS

3—75 gal. Day Imperial, dispersion

2—50 gal. W & P, sigma, jkt.

1—20 gal. Day, sigma, jkt.

1—335 cu. ft. Sprout Waldron horiz steel ribbon mixer, UNUSED

1—Patterson 6′ dia. Dbl. cone blender

1—Sturtevant #9, 150 cu. ft. rot. blender, UNUSED

1—Robinson 2 cu. ft. conical blender, st. st.

1—Mueller T316 SS contin. mixer

CENTRIFUGALS—FILTERS

3—Sharples #C-27 T316 SS Super-D-Hydrators

2—Sharples #C-20 T316 SS Super-D-Hydrators

30—Sharples #AS-16V Inconel Super Centrif.

2—Bird 24″ x 24″ type CH monel, horiz.

1—Tolhurst 48″ dia. susp., T304 SS perf.

6—A.T.&M. 40″ dia. susp., T304 SS, 40 HP

1—Bird 40″ dia. susp., steel, imperf.

1—Tolhurst 26″ dia., susp., steel, perf.

1—A.T.&M. 12″ dia., susp., T304 SS perf.

1—Oliver 5′3″ x 8′ rotary vac. filter, UNUSED

2—Oliver 5′3″ x 3′ rotary vac., T04 SS, ASME

1—Niagara #510-28, 510 sq. ft., T316 SS filter

1—Alco 110 sq. ft. T316 SS pressure filter

1—Niagara #60-30, 57 sq. ft., T304 SS filter

1—Niagara #53-36, 53 sq. ft., T304 SS filter

1—Sparkler #18D, 13 sq. ft. st. st.

2—Sperry 30″ "NI-RESIST" P. & F. filter presses

CLOSE OUT!

CHEMICAL PLANT—ORANGE, TEXAS

1—Struthers Wells 3500 gal. T316 SS jkt. reactor

2—Vulcan 96″ dia. T316 SS bubble cap columns

1—Vulcan 72″ dia. copper bubble cap column

2—Sharples C-20 T316 SS Super-D-Hydrators

1—17,650 gal. T316 SS horiz. tank, 9′ x 36′

1—Struthers Wells 630 sq. ft. T316 SS evap.

5—800 sq. ft. T316 SS heat exchangers

2—1450 sq. ft. T316 SS heat exchangers

3—Worthington 160 ton steam-jet vac. refrig. units

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Type 316 Stainless Steel Equipment

7—Alloy Fabricators Type 316 SS pressure vessels, 4500 gal., complete with agitators and drives, 45 psi.

2—Alloy Fabricators Type 316 SS, 4500 gal., jacketed reactors, complete with agitators and drives.
2—Alloy Fabricators Type 316 SS, 1000 gal., jacketed kettles, 3/8" material throughout.
12—Whitlock Type 316 SS pressure vessels with coils, 270 gals.
3—Whitlock Type 347 SS pressure vessels with coils, 300 gals.
3—Type 316 SS mixing tanks, 6000 gal., complete with agitators and drives.
8—Acme Type 347 SS settling tanks with cone bottoms, 1000 gal.
1—2600 gals. Type 316 SS vertical vacuum receiver.

3—Vertical Type 316 SS activated carbon absorbers, 5'4" dia. x 16'.

1—Struthers Wells 75 gal. Type 316 SS 500 lb. pressure vessel ASME code National Board.
2—Project fabricators type 316 SS vacuum receivers, 160 gals.
2—Pfaudler 500 gal., glass lined jacketed kettles.
1—Pfaudler 20 gal., glass lined vacuum receiver.
1—Haveg, 500 gal., vacuum receiver.
2—Aluminum horiz. 5000 gal. storage tanks.
5—Pfaudler horiz. glass lined storage tanks, 5000 gals.
1—Pfaudler vertical glass lined storage tank, 5000 gals.

4—Rubber lined horiz. storage tanks, 5000 gals., working pressure 45 lbs.
16—Rubber lined vertical storage tanks, 4500 gals., working pressure 45 lbs.

2—Rubber lined vertical storage tanks 2500 gals. working pressure 45 lbs.
4—Patterson Kelley SS condensers, 500 sq. ft.
7—Stainless steel condensers from 50 to 300 sq. ft.
4—Stainless steel packed columns, 18" x 15'.
2—Shriver 18" x 18" SS plate and frame filter presses, 10 chambers.
5—Shriver 42" x 42" wood plate and frame filter presses, complete with hydraulic closing device, 30 chambers.

7—Buflovak Type 316 SS jacketed rotary vacuum dryers, 5'x30', complete with 25 H.P. explosion proof motors and drives

3—Type 316 SS Ter-Meer continuous type centrifuges 4' dia. bowls complete with motors.
3—Readco SS jacketed horiz. blenders, complete with explosion proof motors and drives.

3—Mikro #4TH SS pulverizers, complete with 40 HP explosion proof motors

1—Mikro SS bantam pulverizer, model CF, complete with ¾ HP explosion proof motor.
3—Gruendler SS, lab size, pulverizers.

2—Nash, Model HS-6, Hastelloy B vacuum pumps, with 25 HP motors.
3—Nash, Model HS-6, Type 316 SS vacuum pumps, with 25 HP motors.

3—Nash, Model TS-12, vacuum pumps, with motors.
1—Stokes Type 316 SS, jacketed, rotary vacuum dryer, 2' x 3'.
14—Copper jacketed mixing kettles, 3500 gal. each.
14—Copper jacketed rotary vacuum dryers, 8 x 10.
5—American type 316 SS blower model MD, size 27".
1—Fuller Type 316 SS, airveying system.
1—Aldrich Groff type 316 SS hydraulic triplex pumps, size 2¾" x 4" at 500 PSI.
1—Quimby type 316 SS twin screw pump with 10 hp variable speed drive.
100—Stainless steel centrifugal pumps, all makes and sizes.
2—Powell type 316 10" hydraulically operated flanged and gate valves.
2—Tyler type 38 tandem SS Hum—mer screens, size 42" x 9'8".
3—Williams type 316 SS hammer mills with 100 HP motors.
3—150 gals. type 316 SS jacketed kettles.
3—200 gals. type 316 SS jacketed kettles.
12—Type 316 SS cyclone separators, 5'2" x 10'8" overall.
500 Tons of type 316 stainless steel pipe, fittings, and valves, ranging from 2" to 6".
500 Tons of structural steel.
50—Stainless steel and aluminum hoppers, all sizes.

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CHEMICAL PROCESS EQUIPMENT

1—Hersey Stainless Steel rotary dryer, 3' x 16'
2—American double drum dryers, 42" x 120", ASME N.B., complete with drives and motors
1—Cleveland SS double cone blender, complete with drive and motor, 85 cu. ft.
1—Stokes #412F vacuum pump, complete

AUTOCLAVES, KETTLES AND REACTORS

1—Pfaudler 200 gal. glass lined jacketed reactor, complete with anchor type agitator and drive
1—Struthers Wells type 316 SS jacketed reactor, 2000 gal., complete with agitator and drive
1—Struthers Wells type 316 SS 400 gal., reactor with coils and turbine type agitator and drive, 250# coils
1—Van Alst 250 gal. SS jacketed kettle, complete with SS column and condenser
1—Pfaudler 200 gal. type 316 SS jacketed reactor, 75 psi jacket, 20 psi internal 2-Monel 2500 gal., jacketed autoclaves, 175# jacket, 175# internal
1—Autoclave Engineers type 316 SS autoclave, 1 gal. complete with motor, drive and coils, 1200# working pressure
2—Blaw-Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—18,000 gal. aluminum storage tank

DRYERS

1—Allis Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louvre dryers, Model 207-10, 310-16, 604-20
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
2—Louisville rotary dryers, 8' x 50', SS
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Western Precipitation Corp. SS pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver SS rotary pressure precoat filter, 5'3" x 8'
1—Oliver type 316 SS rotary vacuum filter, 4' x 5'
1—Oliver horizontal filter, 3'
1—GATX SS pilot plant filter, 2' x 6"
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers

THE GELB GIRL—AUGUST 1960

CENTRIFUGES

1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforate basket
1—Fletcher 48" center slung SS centrifuge, complete with perforate basket and motor
4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors
2—Fletcher 40" center slung rubber covered centrifuges with perforate baskets and motors

MIXERS

2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Richmond Engineering type 316 SS 40 cu. ft. horiz. double ribbon blender
1—Baker Perkins Size 20, 2000 gal. double arm jacketed vacuum mixer with double naben blades
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
2—Baker Perkins 20 gal. SS jacketed vacuum double arm mixers
1—Banbury #1 mixer, chrome plated rotor, with 50 HP motor
1—Stokes SS granulating mixer, Model 21 J
1—Entoleter impact mill type PPM-27

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25' plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
4—Davis Engineering Corp. 20,125 sq. ft. heat exchangers, NEW
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Mikro Model 1 SH pulverizer
2—Swenson type 316 SS vacuum crystallizer, 3'6" x 12', 2' x 12'
3—Williams type 316 SS hammermills, Model AK
1—Sprout Waldron Model 501-D pelleter
1—Ross 6" x 14", 3 roll paint mill, complete

1—Blaw-Knox 300 gal. type 316 SS jacketed reactor, complete with anchor type agitator, drive and motor.
1—Cole rubber lined, steel, pressure tank, 1300 gal., ASME code
8—Western States 40" type 316 SS suspended type centrifuges complete with perforated baskets, plows and 40 HP motors. Year built 1953.
1—Buflovak chrome plated double drum dryer, 32" x 90", complete with drive and motor.

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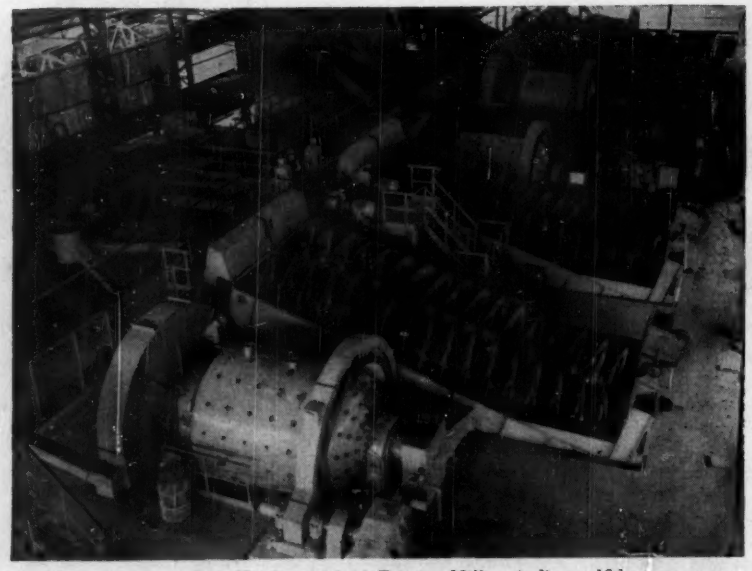
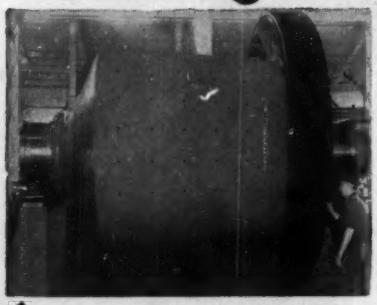


Shown here are four Hardinge 9-3-6-8 Tricone Mills grinding sulfide copper ores and mixed ores in a concentrating plant in the Belgian Congo, Africa.

CORRECT BALL SEGREGATION in the HardingeTRICONE MILLS



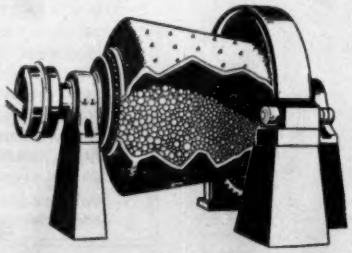
Shop view of a 10½′ Tricone with 9′ long tapered shell.

Highest grinding efficiency and lowest ball and lining wear are common to mills with a correctly segregated ball charge.

The Hardinge Tricone Mill is the only mill providing these essentials to low cost operation without the use of special linings or internal devices, which are subject to wear and are effective through only a part of their wearing life.

The Tricone also occupies less floor space for its grinding volume than any other ball mill built.

Every ball in the Hardinge Tricone Mill "minds its own business!"



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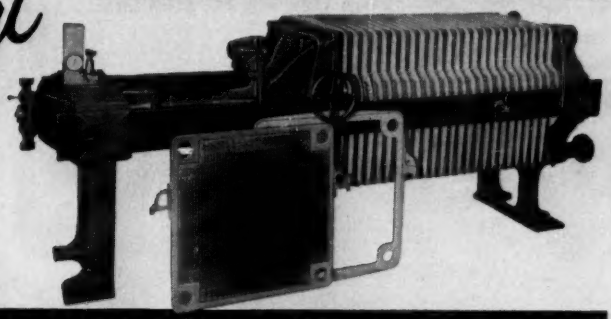

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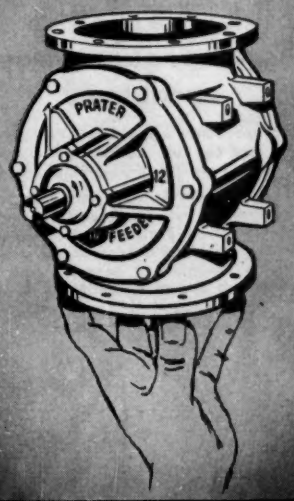

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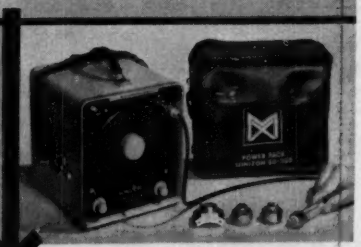
The Fully Transistorized SONIZON SO-300 by MAGNAFLUX



- Measures thickness instantly from one side only.
- Spots corrosion and thin wall in pipes, tanks, valves, casting core shift, etc.
- May be used on practically any solid—from .025 to 2.50" thick.
- Direct readings—as fast as a probe can be moved over the surface.
- Lightweight — measuring unit only 12¼ lbs.
- Easy-to-use—select the range and turn a dial.
- Both quartz and the more sensitive lithium sulphate transducers may be used.

Ruggedly built for industrial use, the new Sonizon SO-300 provides instant engineering-accurate measurements, on steel, cast iron, brass, nickel, magnesium, hard rubber and plastics. Accuracy to ±1% is assured when calibration is checked against known sample of same material.

Complete with high impact-proof carrying case and battery case. Write for further information or demonstration—**MAGNAFLUX CORPORATION**, A Subsidiary of General Mills, 7314 W. Lawrence Avenue, Chicago 31, Illinois.

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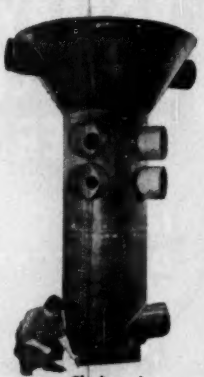

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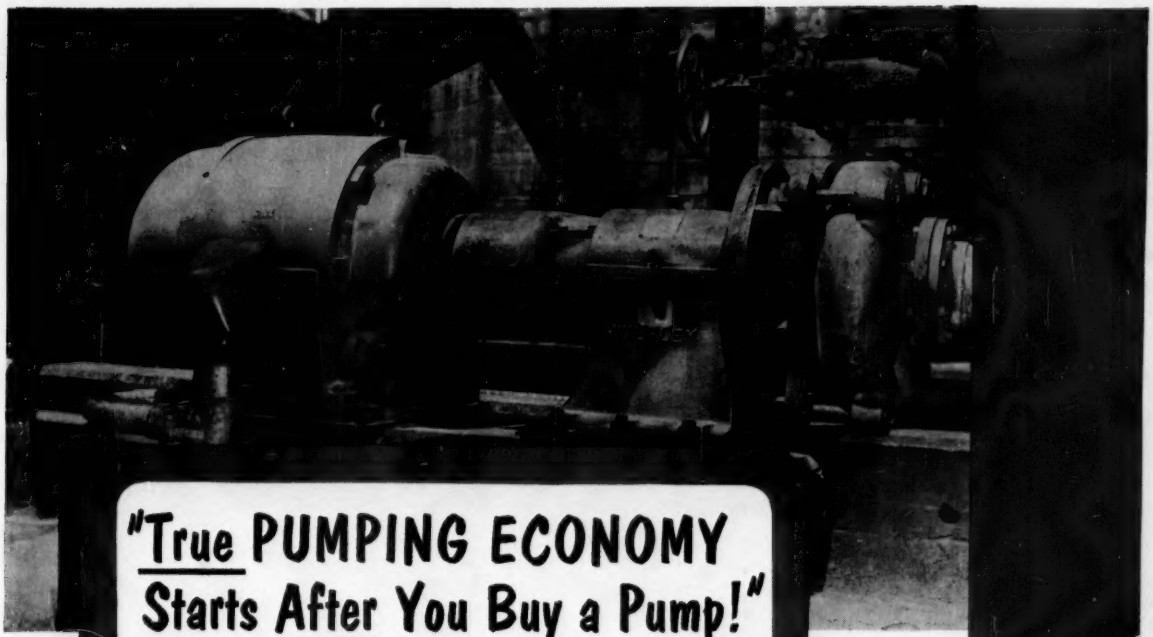

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